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DEVELOPMENT OF A METHOD FOR MEASURING TREND IN RANGER CONDITION OF NATIONAL FOREST RANGES: FINAL REPORT.

BY

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SUPERVISION
Administrative Studies
(Condition and Trend)

Final Report

on

DEVELOPMENT OF A METHOD FOR MEASURING TREND IN RANGE CONDITION OF NATIONAL FOREST RANGES

by

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FINAL REPORT ON DEVELOPMENT OF A METHOD FOR MEASURING TREND IN RANGE CONDITION OF NATIONAL FOREST RANGES

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INTRODUCTION

One of our greatest needs in range management planning is a method for the determination of trend in range condition. Realization of this need brought about the westernwide Range Condition and Trend study begun in 1948, which has been carried out through the cooperation of the six western regions and experiment stations.

Facts on the condition and trend of our National forest ranges are needed in order that decisions may be wisely made. Such facts are necessary for a better understanding of our aims in the administration of forest-range watersheds by the general public as well as range users. We vitally need information on many important range types which will eventually lead to the development of sound condition standards for these types.

Although there have been numerous administrative studies in the past as well as other sources of information which can be drawn upon to depict general trends, there has as yet been little effort expended "to keep stock" through specific regularly scheduled inspections for each and every grazing allotment. With some 10,000 allotments in the West, this may be out of the question to attain even if funds and personnel were adequate. Except in a few isolated instances, there has been but little organized and planned effort to even record condition and trend on allotments generally recognized as "problems." Even though there is a real need for such factual information to facilitate intelligent and skillful range management, it is as yet largely lacking. The basic reason for this

lack of stock keeping is probably because no method of sampling ranges has as yet been devised (or at least as yet recognized as such) which is generally accepted with confidence by range administrators.

The condition and trend study has had four major objectives:

1. To adapt or develop a method or methods that can be used by administration for measuring trend in range condition on western National forest ranges.
2. To consider the soundness and adequacy of present range condition standards now in use.
3. To check the suitability of record maintenance on range allotments as a means of following range trend.
4. To determine what use is being made of repeat photographs in recording range trend.

Field work on the condition and trend study was begun in July 1948 and was devoted to getting acquainted with the range types and conditions in the six western regions--and to a consideration of methods in use by Administration and Research for appraising condition and trend. Significant findings were:

1. No region or station was willing to endorse any one method as the method for testing and ultimate western-wide application.
2. All regions and stations agreed that in order to follow trend in condition that information must be taken periodically on density, floristic composition, vigor, litter, soil erosion characteristics.
3. That the initial step toward development of a method for following trend should be in perennial grasslands and open timber-grassland types in various stages of condition--because they are the most important for range and usually comprise the key areas on an allotment.

4. All agreed that to follow trend most efficiently, we must have permanently located open range plots or transects established within the allotment, trend being determined by repeated measurement of these plots at periodic intervals of time.

During the past two years attention has been focused primarily on the development of a method for measuring range trends. The main problems in the development of a method have revolved around what information should be gathered, how it can be most efficiently gathered on permanently located plots or transects on the open range, and how the field data can be most effectively interpreted. For the 1949 field work a specific method, designated as the "3-Step-Method" was proposed for trial in each of the six western regions. The method tested incorporated many ideas from other measurement methods. It was presented to the field as a preliminary step in the evolution of methods and to stimulate thinking, and not necessarily as a final method for adoption of Administration. The 1949 tests were very encouraging. The "3-Step-Method" was found to be rapid and reasonably accurate. Accordingly the main work in 1950 was aimed at further refinement and actual application of the 3-Step-Method on an allotment basis.

It is the purpose of this report: to point out what elements or factors can and should be measured in following range trend; to consider the magnitude of changes within these factors that can be expected within various periods of time from grazing use and changes in weather; to describe the 3-Step=Method for measuring these factors together with evidence as to its sensitivity and reliability and as to how this method may be best applied on an allotment basis and to recommend the training and personnel necessary to do the job.

NATURE AND CHARACTERISTICS OF CONDITION AND TREND

RANGE CONDITION

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Range condition is generally referred to as "range health." In more technical terms, it is the relative position of a range with respect to its potential productivity as determined by climate, soil, and management. Condition classes are commonly designated as excellent, good, fair, poor, and very poor or deteriorated. Excellent is ideal with no accelerated erosion and the top standard of comparison. Good is generally satisfactory but as it deteriorates to the fair condition class, erosion may become slightly accelerated. The remaining classes are unsatisfactory either as to forage cover or soil erosion rates or both. Criteria for describing each condition class are generally based on [density or] amount of plant cover, floristic composition, vigor, litter and soil characteristics, especially with respect to erosion. It is important that the standards for describing these condition classes be on a firm ecological basis, wherein each condition class corresponds to a stage or substage of secondary succession as determined mainly by grazing use. Any system of classification other than this would be artificial and of little value in pointing management towards a realistic objective.

[Most ecologists recognize that the soil change from bare rock to mature soil is accompanied by a systematic succession of several stages in vegetation (these may also be accompanied by a comparable succession in native fauna). This is known as primary plant succession. Disturbance factors such as fire, cultivation, and overgrazing operate to upset this orderly succession. However, whenever the disturbing influence is removed, the vegetation again moves toward the ultimate development under the prevailing climate. This is known as secondary succession and the vegetation

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stages may or may not be closely similar to the primary successional stages. The secondary stages of plant succession, particularly as influenced by grazing use, are the stages with which the range manager is most concerned since each stage or the next substage above it constitutes his immediate management objective.

In general, the better condition classes have higher infiltration and lower soil erosion rates than the poorer condition classes. In this respect range objectives are similar to those of watershed management. Forage production is greatest generally in the higher condition classes because desirable forage species are vigorous and abundant and soil moisture conditions, as beneficially influenced by a better litter cover and higher infiltration rate, are most favorable for growth. The rate of change in either direction is influenced principally by management and modified by weather. Management is the more significant factor of the two because it can be controlled by man.

Range Trend

Change from one condition class to another, or change within a condition class as for example from low fair to high fair is called range trend. The condition classes may be likened to milestones along a mountain grade. Upward trend on this incline is improvement toward the management objective; whereas downward trend is deterioration or change away from the management objective.

Until recent years both vegetation and soil have been grouped together into the single expression, "Range condition." Similarly trend has included both. Use of the term to include both vegetation and soil has led to much confusion and controversy in field application. In

primary plant succession, soil and vegetation develop concurrently over a long period of time. But in secondary succession as brought about by land management activities the changes in plant cover are usually more rapid than soil changes, at least they are more readily recognized. For example, an improving plant cover may not be accompanied immediately by marked reductions in soil loss and the forage cover may rate a high fair but the soil condition as very poor. Contrariwise the soil mantle may be largely intact but the forage cover depleted. This is especially noticeable on many level mountain meadows and parks. Similar situations may even occur on steep slopes where the original perennial plant cover has been replaced by dense stands of annuals (as has happened in the Great Valley of California), or the spaces between remnants of the original bunchgrasses have become covered with club moss~~es~~ which [have] has prevented marked losses in soil. Vegetation and soil are interdependent in that the amount of ground cover, in the form of living plants (including moss), litter, rock, and erosion pavement, is instrumental in the prevention of raindrop splash erosion and surface movement of soil by runoff. In order to be more specific about the meaning of range condition and to secure uniformity in its appraisal, it seems desirable to separate it into two expressions--[forage or] vegetation condition, and soil condition. Likewise in the determination of change in condition the phrases "vegetation trend" and "soil trend" should be used.

The appraisal of either forage or soil condition, except in borderline cases, is comparatively simple provided the examiner has had adequate training and has the essential criteria available for judging the condition classes. This is not generally true in the determination of current trend

in condition (unless the earmarks of change are extremely strong), particularly if the examiner is unfamiliar with its history of use and has no record of conditions in the past. It is generally unsafe on the basis of field inspection alone to predict with certainty that the change in the future will continue either towards improvement or in the direction of deterioration. The principal reason for this is that the examiner must rely largely on qualitative earmarks such as pedestaled plants or vigor of the key indicator forage species. Furthermore, he must often evaluate trend by inference. For example, if the range is destructively grazed he may infer that if such use continues the trend must be downward. On the other hand, a dilemma arises when the grazing use is variable ~~of~~ or the utilization standards are of questionable soundness. Thus the evaluation of current trend and prediction of its direction in the future by inspection alone is largely a matter of personal judgment arrived at by a mental summary of range trend indicators. This judgment is often colored by either wishful or "purist" thinking.

[Among the more important fundamental concepts that are basic in the determination of condition and trend and which were adopted at the 1944 Methods and Techniques Conference of the Forest Service (47) are the following:

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> "1. Any portion of the range is made up of biological and physical elements which act and react upon one another. These are the elements that go to make up the vegetation, animal life, soil, topography, and climate. Normally these components are in harmonious adjustment with one another, forming a complex, or system, of interrelated parts.
>
> 2. This state of adjustment is not fixed, but fluid, so that the range is not static, but dynamic. The range never stands still; changing weather, variations in use by livestock and game,

flutuating rodent populations and insect infestations, are examples of factors that operate intermittently to alter its appearance. Beneath these more or less superficial influences are more permanent and lasting ones, such as the deepening of the soil and improvement of soil quality by the reaction of plants, the invasion of new species into the stand, and changes in species composition or accelerated soil loss as a result of long continued over use. These later influences determine permanent trend in range condition."

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Current trend may thus be only temporary, since vegetation is under more or less constant change in accordance with fluctuations in the weather and other factors. To follow these natural changes in vegetation is often difficult even for trained ecologists. To follow them adequately and factually on range land under grazing use is doubly difficult--particularly when one attempts to separate the influence of weather from grazing. And yet, it is necessary for the range administrator to be able to recognize these changes and the agents causing them in sufficient time to avert a downward spiral in range condition. Although the range manager must not overlook current happenings as they often foretell future conditions, it is after all the long time trend over periods of 5, 10, and 20 years, with which he is most concerned. Proper appraisal of long time trends is essential to meeting management objectives and for ascertaining the need for adjustments in stocking rates and season of use.

Errors in judgment of range trend are an especially acute problem in administration of public range land as well as in the management of private range. The soundest approach to the solution of this problem on public lands is through intensive training of personnel and the subsequent application of sound field guides and techniques applicable on an allotment basis that will ultimately provide a clear record of the facts. In order to accomplish the latter, there is, as Ellison (17) points out, clearly a need for more and better permanent plots and photographs and for

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increased skill in the interpretation of the changes they reveal. Whenever these records and this skill are lacking, there is an obvious need for caution and conservatism in basing predictions upon indicators observed on the range. Records must portray the significant changes that have taken place in forage and soil between some point of time in the past up to the present. Three questions immediately arise: What should go into the record? How should it be obtained? How can it be interpreted? Since the range administrator's time is usually limited, it is necessary that the record be confined to the main essentials. Delete

In the determination of trend in forage and soil condition several major considerations are involved:

1.—Watershed condition—as measured by erosion rates and infiltration capacity. In general, erosion rates decrease and infiltration rates increase as the plant cover condition improves. However, there are some soil types where the plant cover condition has little or no apparent influence on infiltration. [For example, soils derived from schist on the Roosevelt National Forest had as high or higher infiltration rates in the poor condition as in the excellent.] Although better range condition classes coincide with satisfactory watershed conditions, this does not mean that in order to meet the requirements of the latter the criteria for appraisal are identical. Watershed requirements may be met by cover types made up of non-forage plants and even noxious range species, which from a range viewpoint would be graded as unsatisfactory.

2.—Productivity—as measured in terms of quantity and quality of forage. On grassland types productivity generally increases as the condition improves. This is not necessarily true of other range types. For

example, the forest floor of an open stand of ponderosa pine timber currently of value for grazing, may within a year's time become densely overspread with tree seedlings. As this reproduction grows and increases in size through the years, the shading out and needle smothering of grass causes a natural decline in grazing values which requires subsequent adjustment in stocking rates. Such lands may be excellent for timber and watershed protection and accordingly classed as in satisfactory condition but when regarded from a range viewpoint have greatly reduced value for grazing. In fact, if sufficient tree reproduction survives they may be ultimately classed as waste range. This phenomenon should not be considered as range deterioration.

3. Plant communities—as determined by climate and soil. Plant communities are natural groupings of plants as determined by climate and soil. These are generally in various stages of primary and secondary succession. Major communities such as: Pacific bunchgrass, ponderosa pine, pinyon-juniper woodland (excluding recent grassland invasions), are good examples of grouping plants on a natural basis. Criteria for describing condition classes are generally on a natural type basis. These, however, may recognize several subdivisions a natural type such as may arise from soil depth and moisture conditions—for example, meadows in contrast to upland grassland sites.

Contrasted with natural plant communities are vegetation types set up largely on the basis of aspect such as are recognized in the usual range survey. For example, the "weed" type and the "half-shrub" type generally represent stages in the deterioration of a major plant community. Since they are transitory and artificial their designation

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and use as types should be avoided in considering standards for judging either condition or trend. Furthermore, their use is often a distinct barrier to the development of a sound understanding of ecological principles.

4. Utilization--its influence on trend and ultimate condition. Utilization is the degree to which the current year's forage production is removed by grazing. The degree of utilization determines range trend and ultimately the condition of the range. As pointed out at the 1944 methods and techniques meeting, observations of condition, trend, and utilization, should not be kept entirely separate. Measurements and records of utilization for a period of years can help answer many perplexing problems as to why certain ranges deteriorate while nearby ones improve. Such records provide part of the chain of evidence needed in making changes in management. Although utilization will not be considered to much extent in this report, this lack of consideration is not meant to reduce its importance nor to imply that it is of secondary importance or that it should not have equal rank to condition and trend in the case history of an allotment.

5. Animals--as indicators of condition and trend. The physical condition and productivity of animals is apt to be a tricky indicator of condition and trend of vegetation. In the case of either livestock or game, poor physical condition and low production are generally associated with ranges in poor condition. This is especially true on grassland ranges grazed yearlong. Total forage production per unit area and the nutritional level of the forage closely corresponds with the condition class--the better the condition the better the forage.

On seasonal ranges, with livestock particularly, the trend in animal condition and production is not a very safe criterion of what is happening on the range. This is because animal weights and production are also influenced by the care that is taken of the animals during the time when they are off the range. Furthermore, the last blade of forage is as good nutritionally as the first. This is true on yearlong ranges, too, but the animals are generally forced to remain on the area until the next forage crop comes, subsisting in the meantime largely on "hard-tack" vegetation. Then too, on either seasonal or yearlong ranges the plants which increase and replace the good forage species because of overuse are in many instances good nutritionally but poor for preventing soil loss. In spite of the frequent lack of correlation between animal production and condition of vegetation, their relationship to condition should not be overlooked. With respect to trend, there is a distinct lag in animal weights and deterioration. With upward trend in vegetation the response is more immediate, hence animal weights have an indicator value in such situations.

In the case of smaller wildlife, ranges that are in good condition usually have adequate escape cover for upland birds and small game. Furthermore, rodent populations are seldom excessive. Jackrabbit populations are generally greatest on ranges in poor condition and, as reported by Norris (33), may greatly retard range recovery. Similar unpublished (Reed and Moore) observations have been made with respect to the pocket gopher in Oregon. Where rodent populations are excessive they alone can constitute a sufficiently strong influence as to materially affect trend.

ELEMENTS TO CONSIDER IN MEASURING TREND

The measurement of trend from year to year or over a period of years is an expression of what has happened or is still happening to the density, composition, and vigor of the vegetation and also changes in soil fertility, water-holding characteristics, litter, and soil stability. As will be shown, no one element can be selected as the sole guide to either condition or trend on mountain range lands. In range deterioration, the first sign is loss in vigor of the choice forage plants. On many range types this is generally followed by actual death loss of choice forage plants and their replacement by undesirable species, so that density is largely maintained. In such cases, composition will change. However, on some range types such as the ponderosa pine-elk sedge-pinegrass type of Oregon, there may be little or no replacement so that although density drops, composition may change relatively little. On still other areas, soil losses may be accelerated but condition of both vegetation and soil may be improving, as noted by increasing cover and diminishing soil loss. On high, cool mountain ranges, the amount of litter is an important element to observe but on semidesert ranges in the Southwest litter disappears through rapid oxidation as brought about by the high temperatures and moisture which often occur concurrently. Accordingly, there is need to isolate and appraise separately the various elements which should enter into an appraisal of forage and soil condition for forming a record useful in depicting trend.

Vegetation or Forage Condition

Density--As a Measure of Trend

"Density" as generally recognized by most range administrators, refers to the percentage of ground surface covered by vegetation. "Density"

in the exact sense, according to Hanson (20), refers to the numbers of individual plants per unit area. The average area occupied by an individual is determined by dividing the measured area by the number of individuals. In range reconnaissance "density" may be the crown spread of the leaves and stems as viewed vertically from above or in the case of spreading plants when bunched at an angle of 30 degrees from the vertical. It may be the basal area occupied at the ground surface or when clipped to a one inch height as in the case of charted quadrats. Density may be an expression of both crown and basal area, depending on the method of estimation or measurement involved and particularly if the vegetation is two-storied as in the case of shrubs and grass.

Density will thus vary with the definition and methodology involved and in the exact sense "true density" is a misnomer. "Density index" is more meaningful and provides for further qualification such as "quadrat density," "square foot density," or "range survey density." All these methods measure areal cover but the actual amount will vary greatly with the method. For example, 1 percent quadrat density may be equivalent to 10 percent range survey density.

"Density" in the sense of abundance is not as sound a criterion of change in vegetation as its areal definition because of the extreme variation in size and spread not only between species but also within the same species. For example, one plant of Veratrum can cover 10 square feet whereas hundreds and even thousands of individuals of cheatgrass would be required to cover the same space. In numerous counts of cheatgrass in southern Utah, Hanson (20) lists an average 572 plants per square foot. Within the same species, such as cheatgrass, young stands with

fewer individuals may cover as much actual ground surface as in dense old mature stands. In either case a change in numbers of cheatgrass would have little meaning in trend. The loss of a single Veratrum plant might have significance but if it were a small young plant its loss would not have the same import as the loss of a large well established plant. Other major objections to the plant count methods for administrative use are that they are often extremely tedious and often the plant unit requires precise definition for many different species. Even with precise definitions, errors in the field application may be great (20). Accordingly, for the purpose of following changes in condition of vegetation it seems best to adopt the term "density" in the sense of area occupied.

The density index of all vegetation in itself does not have too much value as a criterion of either condition or trend in vegetation. For example, in the aspen type on the Manti National Forest the density index of basal cover as determined by the loop method on excellent range was 17.7, whereas in the poor condition it was only slightly lower, being 13.7 percent. The excellent condition was made up mostly of good forage plants, whereas the poor consisted mainly of low value species. If the density index for following trend in condition is confined to the better forage and soil holding plants it becomes more meaningful in the record. The total density index is of value, however, in helping to define erosion hazard and in assuring soil stability.

The basal index of density for perennial grasses and weeds is the most sensitive to actual change in cover because it eliminates the errors which would arise in measurement of the crown spread as will occur with differences in size as arise from seasonal growth stage and current

utilization. On the other hand, the crown spread of perennial shrubs, excluding current seasonal twig growth, is the best measurement for a record of trend because the basal stem portion is subject to change in only one direction--increased size.

Density--Magnitude of Change

The magnitude of change that can be expected over a period of time in the density index is an important consideration in the design of a method for following trend. This is likewise true of other elements, such as composition and vigor. The density index is markedly influenced by both weather and grazing pressure. The degree and rate of change varies greatly with climate and soil. In the semidesert grassland and short grass plains, changes are more rapid and of greater magnitude than in the high mountain areas. Drought occurs with greater frequency and is of longer duration in the lower altitudes than in the higher elevations. The magnitude of change in the density index is accordingly greater. Information on this point for the higher elevational ranges is largely lacking. This is unfortunate, inasmuch as National forest lands are generally confined to the higher elevations and knowledge of the magnitude and rate of change that is possible would be helpful in the development of a method for following trend.

Many of the changes in vegetation, herein reported, are based on comparisons between grazed and ungrazed range (fenced exclosures). Aside from the fact that the real differences may have been obscured or magnified by personal error, such differences do not indicate the real magnitude of change. This is because the ungrazed area may have been previously overgrazed prior to the fencing and during the intervening period of years,

whereas the adjoining range may have deteriorated further or even improved slightly. The real change then is the beginning point from which each area started and not necessarily the final difference between the grazed and ungrazed areas.

Change from bare soil to cover.--The magnitude and rapidity of change that can occur from bare ground to a suitable cover of vegetation varies with soil, weather, and the degree of release of the area from grazing pressure. In Montana, in the mountain grassland type, Heady, Clark, and Lommasson (22), observed the changes on a formerly overused sheep bedground with good soil. In 1928 the cover was sparse (mainly scattered niggerhead --Rudbeckia occidentalis), which with release of grazing pressure increased to a 5 percent in 1942. The latter cover included a dozen or more species, several of which represented plants of the original plant cover. In a study of the microclimate of subalpine grassland in Utah, Ellison (16) concluded that soil surfaces essentially bare of perennial vegetation may persist in that condition for many years. Also that adjacent surfaces covered with dense rhizomatous vegetation such as Penstemon rydbergii change very little in appearance over similarly long periods and that new plants become established within the Penstemon patches and not in the bare spaces, where they are most needed for soil protection.

There is little or no published information on the time required for a range to deteriorate from the original cover to nearly bare surfaces. In most instances, it has taken 40 to 50 years of continuous heavy grazing. In general, the big problem of management is not concerned with the areas entirely or nearly devoid of vegetation but with the vast areas of range which have varying remnants of the original cover and are in unsatisfactory condition. The magnitude of changes in the density index within these areas is most logically considered by major plant communities common in the West.

Semidesert grassland.--Quadrat density data for black grama range on the Jornada Experimental Range in southern New Mexico indicate the magnitude of changes arising from weather, where the annual rainfall is low. As shown in table 1, the quadrat density of black grama on ungrazed range

Table 1.--Average plant area of black grama per square meter on conservatively grazed and ungrazed areas, 1915-1922 (After Nelson)

Year	Conservatively grazed	Ungrazed	Annual precipitation
	(Cm²)	(Cm²)	(In.)
1915	507	548	8.12
1916	495	537	6.80
1917	388	462	3.62
1918	213	337	8.46
1919	195	227	11.48
1920	366	433	9.33
1921	436	534	4.81
1922	148	107	8.49
Avg. 1915-1922	305	354	6.79

fluctuates greatly with rainfall. This fluctuation is not necessarily immediate but depends on the intensity and duration of drought. In 1916, although it was a dry year, density change from the previous year was not significant. But with the following year, also characterized by drought, quadrat density by 1918 had dropped some 40 percent from what it was in 1915. In 1922 the change was precipitous, there being an 80 percent loss resulting from the severe drought of the previous year. Similar changes with weather occurred on the conservatively grazed areas. Unfortunately, data are lacking for areas submitted to heavy grazing year after year which show the deterioration in cover from that of the original. However, Nelson (32) reports that on heavily grazed range the density change from 1915, when the average was 154 cm^2 per square meter declined to 30 cm^2 in 1918 and to 25 cm^2 in 1922, and concluded that drought losses were

intensified by heavy use. The heavily grazed portion of the range observed by Nelson was largely unutilized prior to the late 90's, because of lack of permanent stockwater. Hence, the difference between 507 cm^2 and 154 cm^2 on the heavily grazed area in 1915 can be largely ascribable to reduction caused by too heavy grazing use during the previous period of about 20 years.

Shortgrass.—Similar and as marked changes resulting from weather and grazing use in shortgrass ranges of the Great Plains have been observed by numerous workers (1, 2, 3, 4, 29, 47, 51, 52). In a study of prairie vegetation in 1949 following partial recovery from the great drought of the 30's, Weaver and Albertson (50) pointed out differences arising from grazing use. A blue grama-buffalograss area ungrazed for about 10 years and which had previously been moderately grazed had a percentage basal cover (quadrat density) of 46, an adjacent area moderately grazed for 40 years —37, and a range overgrazed prior to 1935 but since then ungrazed—21%.

In the blue grama—needlegrass vegetation of southern Alberta; Clark, Tisdale, and Skoglund (11) observed the influence of weather and grazing. As shown in table 2, the basal area (quadrat density) of perennial

Table2.—Average basal area of perennial grasses in quadrats located on ungrazed and moderately grazed shortgrass range (After Clark, Tisdale, and Skoglund)

Character of use	Basal area occupied in percent 1929	1932	1936	1939
Ungrazed	26.05	23.75	21.42	14.12
Moderately grazed	25.33	23.35	17.13	15.20

grasses fluctuated similarly on both moderately and ungrazed range. They concluded that while moderate grazing intensifies to some extent the unfavorable effects of drought, it seemed to be a factor of less importance than climate in modifying the plant cover. On the other hand, "serious

and progressive deterioration of the plant cover results from overgrazing over a period of years and climatic fluctuation while affecting the rate of depletion is not likely to alter the general trend."

Sagebrush-grass.--The magnitude of change that is possible in the sagebrush-grass type is influenced not only by climate, soil, and character of use but also by the amount of shrub cover. If the latter is dense the amount and rate of change in the understory cover will be small and slow. On the other hand, if shrubs are sparse, competition with the understory will be less and changes more rapid and of greater magnitude. An indication of the effect of the shrub cover on the density of perennial grasses is reported by Craddock and Forsling (13) in table 3. These

Table 3.--Changes in basal area of perennial grasses on meter square quadrats under heavy late fall use by sheep and ungrazed (Dubois, Idaho)

Year	Heavy late fall use	Ungrazed
	(Cm^2)	(Cm^2)
1923	882	668
1926	826	960
1927	513	736
1929	413	484
1930	377	476
1931	555	515
1932	630	542

authors explain the apparent paradox of perennial grass cover under heavy grazing in the late fall being maintained and even exceeding that of ungrazed range as follows: Under grazing use there was a loss in shrubs and consequent lessened competition for available soil moisture. Grazing in the late fall by sheep, after the grasses have reached maturity, apparently favors the grass cover since these plants are not readily taken by sheep

at that time. In contrast, spring use on sagebrush-grass range by sheep is injurious and the magnitude of change in the palatable cover may be great as indicated in table 4. Within six years, under heavy continuous

Table 4.—Magnitude of change in cover of vegetation under heavy continuous spring-late fall use and heavy late fall use only (After Craddock and Forsling)

Grazing treatment	Class of plants	Total cover 1924	Total cover 1930	Palatable cover 1924	Palatable cover 1930
		(Pct.)1/	(Pct.)	(Pct.)	(Pct.)
Heavy continuous spring-late fall use	Browse	11.62	20.12	1.24	1.47
	Grass	11.34	3.43	7.94	2.62
	Weeds	6.06	1.20	2.93	.55
	Total	29.02	24.75	12.11	4.64
Heavy late fall use only	Browse	12.04	11.41	1.34	1.09
	Grass	11.42	13.09	7.88	9.85
	Weeds	6.54	7.60	3.18	3.94
	Total	30.00	32.10	12.40	14.88

1/Range survey density.

spring-late fall use there was a reduction of 67 percent in grass cover and 81 percent in weeds; whereas with heavy late fall use only, these classes of forage increased about 25 percent. Differences in total cover in either case did not indicate effectively the real change in condition as was the case with the palatable cover.

Where grazing is heavy year after year, thickening of the original shrub stand, or invasion of grassland by sagebrush is a common occurrence. These changes in cover may be fairly rapid and have been followed by repeat photographs. (Fig. 1). In contrast, original invasion colonies of sagebrush whose increase has been arrested through moderation in grazing use, may persist for many years according to Lommasson (28).

Open timber.—Information on the open timber type as to the magnitude of change in cover resulting from weather and particularly as influenced by grazing use is largely lacking. This is unfortunate since this type is

Figure 1.—Top photo (41735A) taken in 1919. Sergeant Mountain Fishlake National Forest, Utah, showing a sparse stand of big sagebrush. Area, at the time of photo was reported to be overgrazed. Lower photo (no W.O. number) taken in 1943 (by Ray J. Davis) shows a marked increase in shrub cover during 24 years, primarily sagebrush.

the most extensive range area on National forest lands, covering some 65 million acres in the western forests.

As in the case of shrub cover, changes in the forage cover are influenced by the amount of tree cover and the establishment of new reproduction. Decline in the grass density resulting from establishment of tree reproduction has been reported by Arnold (5) in the ponderosa pine type of the Coconino National Forest, Arizona. Portions of his data are presented in table 5. Pine seedlings established in 1919 had small effect

Table 5.—Changes in perennial grass cover in ponderosa pine type on ungrazed areas as affected by pine reproduction (From Arnold)

	Percent cover of perennial grasses 1/					
	1921	1924	1925	1933	1938	1941
A-Open-no reproduction	11.43	14.08	27.53	28.51	22.00	13.82
B-Pine reproduction established in 1919	10.63	11.90	24.41	17.76	9.45	4.69
Difference A minus B	.80	2.18	3.12	10.75	12.55	9.13

1/Basal cover from averages of quadrat data.

on the cover until after 1925. Subsequent growth and increase of demand for moisture by pine reproduction had a depressing effect on grass cover. Fluctuation because of weather in the cover of perennial grasses on open areas and where pine seedlings were established is also marked even though both areas were ungrazed.

Composition of Vegetation— As a Measure of Trend

Composition of vegetation is the assemblage and relative abundance of the various plant species making up the cover of vegetation. In most plant communities it is the most important criterion for judging the condition of vegetation. A periodic record of composition is likewise of equal importance in the determination of trend. This is so, because the

floristic composition is the principal means of describing successional stages and condition classes. Sampson (41) concluded that if the successional stages of the conspicuous species are known and their increment from year to year determined, the examiner is in a position to declare definitely whether or not the range is improving.

As yet, our knowledge of the secondary stages of succession is incomplete for many major plant associations. This problem is not insurmountable, provided composition is used as a base for analysis and interpretation. The individual plant species constitute excellent indicators of range condition because they have been screened by the factors of the environment. Their presence or absence, their rate of growth and success in reproduction are all the result of such environmental influences as weather, soil, grazing use, and the competition from other plant species. Composition, to be properly interpreted, must be broken down into its most meaningful segments.

On the basis of reaction to grazing use, as forage, and soil holding agents the species for any plant community can be placed into three groups, namely: (1) Desirable, (2) intermediate, (3) undesirable. The basis for doing this has a sound ecological basis. Sampson (41) in Utah found that an appreciable increase of a species invariably reveals one of two stories. If the invading species are annuals and hence lower in the succession than the predominating vegetation, the range is being unwisely utilized. If the incoming plants are desirable bunchgrasses and thus higher successionally than the type as a whole, improvement is indicated. Where the negative indicators are crowding out the more permanent and desirable species, remedial measures are needed. In Colorado, Hanson, Love and Morris (21) in 1931 observed that by grouping plants on the basis of

grazing value for cattle—into three classes, desirable, undesirable, and immaterial—the comparison of effects of different systems of grazing was greatly facilitated.

More recently, Smith (45), in central Oklahoma in 1941, observed the behavior of plant species under conditions of moderate and heavy grazing. He grouped the species in accordance with deterioration and recognized four groups under moderate grazing:

1. Species forced out or greatly decreased in abundance.
2. Species which increase.
3. Species which invade.
4. Species which are more or less unaffected.

Only the first three groups are recognized under overgrazing. Similarly, Weaver and Hansen (51) in Nebraska classified plants according to the manner in which they respond to grazing:

1. Those which decrease, including prairie grasses and forbs.
2. Those which increase, both prairie grasses and forbs.
3. Those which invade (on the whole these are "not a component of the true prairie") grasses and weedy forbs.

In Texas, Dyksterhuis (14) found that an increase in the coverage of Andropogon scoparius afforded a measure of the rate and extent of ecological succession on range land while increase in Stipa leucotricha indicates ecological retrogression. This and similar studies led to an ecological classification of species based on response to grazing in which plants are grouped as: (1) decreasers, (2) increasers, and (3) invaders. The "decreasers" and "increasers" being species of undisturbed and relatively stable or climax plant communities whereas the "invaders" are not, and are plant species characteristic of disturbed areas. When the relative coverage of

the three groups of species is plotted on a graph against the varying percentages of climax vegetation occurring within the several condition classes, a downward curve is shown for the decreasers and increasers with deterioration from the climax whereas an upward curve is shown for the invaders. According to Dyksterhuis (1949) this is a departure from the stage or stair-step idea of evaluating range condition, since the position of a range on these curves is readily determined from the composition.

The previously mentioned suggestion of grouping plants into: (1) desirable, (2) intermediate, and (3) undesirable is based on a similar concept in that the groupings are based primarily on reaction to grazing use. Hence the groups of plants are comparable, desirable being similar to decreasers, intermediate includes plants which increase, and undesirable lists the invaders. However, designation of the groups as recommended in addition permits ready placement of good but exotic forage species with the desirable natives and placing species which do not seem to react markedly with grazing use or about which we have meager knowledge into the intermediate group.

As an example of how such groupings may be useful to the examiner, let us consider briefly the aspen type, with its associated openings as it occurs in the northern parts of Utah and Colorado. The aspen type is characterized by a profusion of subtypes highly complex in make up (with several hundred or more species), each of which is difficult to interpret. These represent, in the main, a confusing array of different stages of deterioration. A good portion of this confusion may be eliminated by placing the common key indicator plants into groups wherein the plants in each group are "ecologically equivalent." To illustrate this point, table 6 is presented.

Table 6.—Key indicator plants of range condition in the aspen type

Group I Desirable 1/	Group II Intermediate 2/	Group III Undesirable 2/
Osmorhiza occidentalis (Sweetanise)	*Geranium* spp.	*Madia* spp. (Tarweed)
Mertensia spp. (Bluebells)	*Rudbeckia* spp. (Coneflower)	*Polygonum* spp. (Knotweed)
Heracleum spp. (Cow parsnip)	*Wyethia* spp.	*Taraxacum* spp. (Dandelion)
Delphinium barbeyi (Tall larkspur)	*Thermopsis* spp.	*Bromus tectorum* (Cheatgrass)
Senecio serra (Butterweed groundsel)	*Lathyrus* spp. (Peavine)	
Agropyron trachycaulum (Wheatgrass)	*Symphoricarpos* spp. (Snowberry)	
Elymus glaucus (Blue wildrye)	*Achillea lanulosa* (Yarrow)	
Stipa columbiana (Subalpine needlegrass)	*Bromus carinatus* (Mountain brome)	
Phleum pratense (Timothy)	*Stipa lettermani* (Letterman needlegrass)	
Calamagrostis rubescens (Pinegrass)	*Sambucus* spp. (Elderberry)	

1/Abundant and dominant and except for pinegrass (*Calamagrostis rubescens*) occur in varying mixtures.
2/Commonly occur in relatively pure stands.

In placing the plants within these three groups for the aspen type no set formula can be arrived at with respect to an exact relative percentage composition of perennial grasses and desirable weeds. A range with desirable perennial grasses predominating should be rated equally as high as one where choice weeds predominate. That is, both may be classed as either "excellent" of "good." Solid stands of single species such as *Geranium* spp., *Wyethia* spp., and *Rudbeckia* spp., indicate unsatisfactory range condition. However,

in the case of pinegrass solid stands of this species are probably a natural phenomenon, resulting as a carryover from coniferous stands destroyed by fire and replaced by aspen, i.e., lodgepole to aspen. Such areas should be classified as "poor for range" but otherwise in satisfactory condition from a land-use viewpoint. Grouping plants in this manner also serves to set up broad management objectives. For example, the objective for the range manager on a range with Group III plants predominating becomes the plants in Group II, and the ultimate objective is the Group I plants.

Composition--Magnitude of Change

The magnitude of changes in composition that may occur because of climate and land use are as great and as rapid as in the case of the index of density. Although weather bears an important influence on composition, it is on the whole superficial or relatively temporary. A dense stand of perennial bunchgrasses may be greatly thinned and some species formerly dominant may become minor constituents because of prolonged drought. Annual species may even for a year or two become abundant but the replacement will not be a permanent situation as commonly occurs with long continued over use. Changes as caused by grazing may result in removal of the desirable species so that the seed source for their reproduction is essentially eliminated. Then too, replacement by undesirable species may completely occupy the site so that moderation or even complete protection from grazing use has little beneficial effect in restoration of the original species. For example, the Provo City watershed, Utah, has many tarweed infested areas still dominated by this plant even after some 15 years of protection from livestock grazing. In some instances the changes as caused by such factors as grazing and fire may be spectacular as the change in aspect from open grassland to a shrub or tree dominated landscape. It is

for this reason that it is important in following the trend that non-forage plants such as pine or juniper be included in the composition. Such plants are generally ignored (except for designating type aspect) in the forage plant inventory prepared in range surveys.

In observing magnitude of change, composition when expressed in relative abundance should be used with caution. For example, the actual basal cover of blue grama might change very little within a 10-year period, but may show a marked change on a percentage composition basis because of increase or decrease of other species. Improvement in this instance would be determined by the kinds of plants increasing or decreasing. The magnitude of change when placed on a percentage basis for each individual species may also be misleading. For example, Sandberg bluegrass having a basal cover of 0.05 percent might increase 500 percent to 0.25 at the same time on the same site. Junegrass with an initial cover of 2.00 might increase only to 3.00. Obviously the change in the latter species is of greater actual magnitude even though the percentage change is a good deal less. Another situation is encountered in the change in direction of one species while an apparently equivalent species is changing in the opposite direction; as pointed out by Ellison (17), this is simply a reflection of our own lack of ecological knowledge.

Semidesert grassland.—Changes in the composition arising from weather and grazing use on a mixed grama community grazed heavily yearlong are shown in table 7. The data were obtained from charted meter square quadrats on an area on the Santa Rita Experimental Range in southern Arizona. Although there are up and down fluctuations from one period to the next, the general trend both in basal area and in percentage composition for black grama (one of the climax species) and for the grasses

grouped as other desirables is markedly downward. On the other hand, Rochrock grama, a secondary and short-lived species, rapidly increased in the percentage composition of the grass stand. Wide fluctuation in this species because of weather is apparent. These changes occurred within a 13-year period where the average annual rainfall is about 14 inches. The trend in total cover is not significant.

Table 7.--Changes in composition of a perennial semidesert grassland as caused mainly by heavy yearlong grazing use

Year	Black grama		Other desirable grasses		Rothrock grama		Total all grasses
	Cm^2	Pct.	Cm^2	Pct.	Cm^2	Pct.	Cm^2
1922	337	54.8	220	35.8	57	9.3	614
1924	168	47.3	85	23.9	102	28.7	355
1926	115	31.5	79	21.6	171	46.8	365
1928	135	49.1	60	21.8	80	29.1	275
1929	158	23.9	89	13.5	414	62.6	661
1935	39	19.4	6	3.0	156	77.6	201

Pct. = Percentage composition
Cm^2 = Square centimeters basal area per square meter

In following the trend in composition, the presence or absence of minor species is often indicative of change in condition. Although changes within any one species are extremely difficult to follow, when grouped together, significant changes in the composition are readily observed. As reported by Canfield (9), the greater the number of different grasses found in mixed grama grasslands the better the indications that good management prevails. As an example of this relationship several grass composition patterns of semidesert grassland on the Santa Rita Experimental range are presented in table 8. The difference in size of the group listed as "other desirable grasses" as these occur on grazed and protected range is apparent. This grouping includes such grasses as hairy grama, tanglehead, Arizona cottongrass, Texas timothy, green sprangletop, plains

Table 8.—Grass composition patterns characteristic of different kinds of grazing use (After Canfield __)

Grasses	Range depletion after heavy grazing	Range improvement: Conservatively grazed for 5 years	Range improvement: Ungrazed for 5 years	Range improvement: Ungrazed for 25 years
	(Pct.)	(Pct.)	(Pct.)	(Pct.)
Sideoats grama	6	14	18	10
Black grama	5	5	10	7
Threeawn grasses	5	11	15	9
Other desirable grasses	10[1]	19	26	56
Slender grama	49	44	27	15
Curlymesquite	13	4	2	1
Rothrock grama	12	3	2	2
Total	100	100	100	100

1/ A grouping of many good forage species, most of which are minor constituents in the composition but are key indicators of good condition.

lovegrass and bush muhly, all more or less minor species, but which collectively become more important as condition improves. In grouping plants by this means care must be observed in placing only those together which are essentially ecologically equivalent.

Shortgrass.—Changes in the composition of shortgrass vegetation arising from weather and grazing use have been reported by many observers (loc. cit.). Albertson and Weaver (50), following an intensive study of the effects of the great drought of the 30's on prairie vegetation concluded that the areas suffering the least degeneration were those areas which were grazed most judiciously. In a subsequent paper (3), these workers presented data, table 9, showing the extremely rapid changes that may occur in the shortgrass community. The astounding increase of buffalograss from 61 percent basal cover in 1940 to 85.9 two years later is reported as not being unusual. Such rapid changes seldom occur with perennial plants in the higher mountain communities.

Table 9.—Basal cover of blue grama and buffalograss before drought (1932), at its close (1940), and during years of recovery on grazed and ungrazed range (After Albertson and Weaver)

Year	Ungrazed (after 1932)			Moderately grazed			Heavily grazed		
	Bgr	Bda	Total	Bgr	Bda	Total 1/	Bgr	Bda	Total 1/
1932	2/ 44.3	44.3	88.6	-	-	-	-	-	-
1935	-	-	-	-	-	49.2	9.0	12.0	22.1
1939	13.0	9.3	22.3	14.4	12.3	27.8	10.0	8.3	19.4
1940	10.3	9.2	19.5	18.2	8.3	27.6	7.3	6.1	13.6
1941	13.9	41.3	55.2	22.8	19.9	43.2	17.7	40.9	58.7
1942	14.9	79.8	94.7	29.0	42.2	71.3	7.2	85.9	93.3
1943	21.8	65.9	87.7	22.3	53.4	75.9	15.1	78.2	93.8

Bgr = Blue grama, Bda = buffalograss.
1/Total includes other minor grass species.
2/Percent basal area from square meter quadrats.

Costello (12) working in northeastern Colorado observed the recovery of native range on abandoned fields. The rate and nature of succession following abandonment was influenced by a complex of factors including rainfall, wind movement, and soil drift, grazing pressure, kind of livestock, season of use, number of years of cultivation, rodents, insects, slope and soil type. A summary of the significant data on rate of change in composition is presented in table 10. Continued heavy grazing pressure alone

Table 10.—Changes in vegetation following abandonment of plowed land in mixed prairie association of northeastern Colorado (After Costello)

*

Number of years following last cultivation	Class of vegetation			
	Perennial grasses	Forbs	Shrubs	Total
	(Pct. 1/)	(Pct.)	(Pct.)	(Pct.)
5	T	5.30	0.0	5.30
9	2.99	3.50	.27	6.76
14	6.91	2.07	.42	9.40
20	8.78	.81	1.40	10.99
30	12.37	.36	.32	13.05
40	18.51	2.60	1.27	22.38

1/Square foot density index.

may maintain almost indefinitely the weed stage shown as characteristic of

the area listed as 5 years following cultivation. Costello further observed the effect of dry and wet years pointing out that "succession advanced farther in the 6 year wet period beginning in 1938 than in the 12 to 15 years preceding that date, a period characterized by deficient rainfall."

Sagebrush-grass.—The magnitude of change in composition of desirable species on the sagebrush-grass range, as in the case of density, is greatly affected by the degree of competition which prevails from the shrub cover. As discussed previously, in connection with table 4, a considerable change occurred within a 6-year period of heavy-continuous spring-late fall sheep use. Where the range was used heavily in the late fall only, the year to year change was probably small but amounted to a final total of 25 percent improvement in the palatable species.

Piemeisel (39) has reported rapid changes in the composition of annuals, following the removal of sagebrush and subsequent abandonment. Russian thistle predominated the first two years, mustards the third, and fourth, and cheatgrass from the fifth year on. Cheatgrass "starts as a solitaire, a beginning age; then a cluster of a few individuals, the young age; then a dense stand, the mature age; and finally a very dense stand, the degenerate age."

Open timber.—As in the case of sagebrush, rate of change in the herbaceous cover in the timber types is not only affected by weather and grazing use but also by competition from woody species. By grouping the species of the herbaceous cover into three classes; grasses which escape or withstand heavy grazing, grasses highly sensitive to grazing damage and weeds; Arnold (5), in northern Arizona, found a distinct relationship with varying amounts of tree and shrub canopy on ungrazed range. All classes of vegetation decreased with increasing canopy. The total line transect

density of all classes of both grazed and ungrazed areas decreased from about 6 percent on areas with no overstory to 1.5 where there was 100 percent crown canopy. It is for this reason that plots or transects for following trend should be located within the openings of the timber where the forage occurs and where the bulk of the grazing by livestock takes place. Further analysis of Arnold's data, table 11, indicates too that there is less natural fluctuation from weather, in the composition of grasses, when plots are placed in natural opernings of the pine timber than when located in areas where pine reproduction is being established. It is probable that wider range in the ratio values shown in the areas affected by 1919 pine reproduction are to a greater extent affected by changing weather, including reduction of light by shade. (table 11).

Table 11.—Changes in ratio of resistant group of grasses to sensitive group of grasses on ungrazed range as affected by pine reproduction (From Arnold's data)

Area	Ratio of resistant grasses to sensitive grasses					
	1921	1924	1925	1933	1938	1941
Open—no reproduction	1/ 1.9	2.5	2.8	2.5	2.4	2.7
Pine reproduction established 1919	4.3	4.5	6.5	4.2	2.8	6.8

1/ Based on ratio of percentage composition derived from basal area quadrat density, i.e., 1:1.9 = ratio of resistant grasses to grasses sensitive to grazing.

Magnitude of change in the composition of the herbaceous cover in the aspen type in Utah during a 20-year period has been followed by repetition of range survey type writeups. As shown in table 12, there was a 50 percent decrease in total density. This is probably not an actual change but a result from a change in concept of range survey density. However, the changes in composition can be regarded as significant.

Table 12.--Change in percentage composition of herbaceous cover in aspen type during period 1926-1946, Uinta N.F. Utah (Data furnished by Dean Phinney, Region 4)

	Year of Range Survey	
	1926	1946
Density	0.5	0.25
Composition	Pct.	Pct.
Grasses	15	10
Bromus carinatus	9	5
Agropyron trachycaulum	0	4
Bluegrass spp.	4	T
Other grasses	2	T
Weeds	56	80
Osmorhiza spp.	4	T
Mertensia (tall spp.)	3	5
Lathyrus spp.	4	15
Rudbeckia occidentalis	5	30
Veratrum californica	2	5
Madia glomerata (tarweed)	0	10
Other weeds	38	25
Shrubs		
Sambucus spp.	29	10
Symphoricarpus spp.	11	7
Other shrubs	12	3

The change is especially evident in: (1) The invasion of the area by Madia glomerata or tarweed, (2) the marked increase in "fall feed" species, notably Lathyrus, Rudbeckia, and Sambucus. The total of these species increased from 20 percent of the composition in 1926 to 52 percent in 1946. Since these species are unpalatable until fall, when frost occurs, their increase is encouraged since they are uninjured by grazing during the critical period of growth. The area, in question, is on a heavily utilized sheep range. The magnitude of the year to year changes has apparently been small. If heavy summer grazing use continues, it may be predicted that "fall feed" species and noxious tarweed will in time become the dominant vegetation. Once the site has become occupied by these species further change to a desirable cover will be slow even though all livestock grazing were eliminated.

Changes in the composition may be of large magnitude and extremely rapid from year to year even on grazed range, if by some means the undesirable plants occupying the site can be eliminated. The elimination of Klamath weed (Hypericum perforatum) on openings within timbered range in northwestern California by introduced insects as reported by Huffaker and Holloway (24) is pertinent. Their data shown in table 13 (1949 and 1950 as yet unpublished) indicates a spectacular increase in the desirable species. Dr. Huffaker told the writer that many areas long regarded as the "annual type" had been with elimination of Klamath weed rapidly converted to the choice perennial cover dominated by Danthonia. The data are of further interest in that they were obtained by a method basically similar to the loop method which is presented in this report.

Table 13.—Percentage changes in minute quadrat dominance of three desirable forage plants resulting from elimination of Klamath weed by insects introduced in 1946 (Data furnished by C. B. Huffaker)

Plant species	1947	1948	1949	1950
Klamath weed	77.6	0.0	0.0	0.0
Danthonia californica	6.1	9.2	16.3	14.8
Bromus hordeaceus	9.2	33.2	44.9	32.7
Desirable legumes	1.0	6.1	1.5	11.7
Total 3 desirables	16.3	48.5	62.7	59.2

Forage Plant Vigor —As a Measure of Trend

The vigor of the forage species is an important criterion of condition. It is an even more important indicator of trend. Principal objections which have been raised to its use for either condition or trend are: (1) Vigor is obscured by the effects of current weather, (2) widely spaced climax perennials may become more robust on deteriorated sites than in the original climax condition, (3) vigor is difficult to describe or measure.

In spite of these difficulties, the element of vigor should not be overlooked in measuring trend because a change in vigor is usually the forewarning of later events to come. Furthermore, vigor is not obscured by current weather and it can be evaluated. For example, on the Flagstaff allotment, Lewis and Clark National Forest, Montana, a large part of the range is in good condition. Within this part, an exclosure fenced in 1936 was examined in 1950, a good season for plant growth. Casual inspection of the grazed range and the fenced plot revealed little difference in the vigor of the key indicator species, rough and Idaho fescue. Yet, measurement of maximum leaf length on randomly selected plants indicated the following at the time the range was opened to livestock grazing: rough fescue 18 inches inside the plot; 12 inches outside; Idaho fescue 6 inches inside, 4 inches outside and open to grazing.

Vigor--Magnitude of Change

Information on the magnitude of change that may occur in forage plant vigor because of grazing use is meager. Change in vigor is effected not only by intensity of grazing use but also by time of grazing. As reported by McCarty and Price (30), grazing at the height of flower stalk production is most injurious to perennial forage grasses. A. L. Hormay, working in the ponderosa pine-bunchgrass type of northern California has observed the effect of clipping on Idaho fescue (data unpublished). Two series of plants, clipped and unclipped at different times in the season, were staked out in 1946. On the clipped series, herbage was removed four years in succession to a 1-1/2 inch stubble height. Observations made in 1950, at the end of the growth season, indicated a 70 percent death loss and an average maximum leaf length on the remaining plants of 4.5 inches, on the series clipped at the height of flower stalk development. On the unclipped

series no death loss had occurred and the average maximum leaf length was 7.1. Idaho fescue plants clipped after flower stalk development had no death loss and response in leaf length was not significant. Similar clipping studies with Wyethia mollis, which is eaten by cattle in the fall showed no death loss and no reduction in vigor.

Although Hormay's studies probably do not simulate exactly what would have occurred with actual grazing, they do indicate that removal of herbage during the period of most active growth is most injurious to perennial grasses.

Unpublished data from the Manitou Experimental Forest in Colorado indicates that a marked change in vigor from intensity of use can occur within 5 years. As shown by the data presented in table 14, there is a marked difference in the leaf length of Arizona fescue and mountain muhly between range that is heavily grazed and that which is moderately or lightly grazed.

Table 14.--Differences in forage plant vigor as influenced by intensity of grazing use (Data from Manitou Experimental Forest)

Stocking rate	Arizona fescue 1947	Arizona fescue 1948	Mountain muhly 1947	Mountain muhly 1948
	1/			
Heavy	6.8	3.9	1.9	1.8
Moderate	10.6	10.3	4.2	4.8
Light	11.6	12.7	4.5	4.9

1/Height in inches at start of grazing season.

Recovery in vigor as brought about by reduced grazing use has been observed on the numerous fenced enclosures established in the Southwest. Here the usual period of time required for measurable differences to occur between the ungrazed areas and adjacent heavily grazed range is from 3 to 5 years. Response in vigor usually precedes either increase in cover or improvement in composition.

Reproduction

The facility with which a plant reproduces is sometimes listed as one of the characteristics of vigor. Most ecologists, however, regard them as separate factors. The age of most range plants, except shrubs and trees with definite growth rings, is difficult to determine with exactitude. Most plants, however, can be separated into broad age groups. Age class distribution is the relative abundance of seedlings, young, middle aged, and old plants. It is an element which should be observed in trend because the nature, kind, and abundance of reproduction may be indicative of more rapid changes to follow in the composition. For example, a range with perennial bunchgrass and scattered mature sagebrush plants may have profuse seedlings of the latter, together with numerous well established young plants. If the factors favoring sagebrush establishment, such as overgrazing in the early spring, remain in effect then sagebrush will thicken and eventually become dominant.

Age class distribution is not too reliable as an indicator of condition because it is seldom that the age classes will assume a "normal" distribution. Reproduction of forage plants is similar to that of timber in that good seed years must be followed by favorable weather for germination and survival of seedlings. For example, in the Southwest good ponderosa pine seedling years occur about once in 9 years and with herbaceous perennials the cycle is about once in 4 or 5 years. Another factor operating against a normal distribution of age classes is competition from plants already established. This is especially true where the site is fully occupied by deep rooted, long lived perennials or by persistent soil moisture robbing annuals such as tarweed.

Significant Findings as Related
to Measurement of Trend

In the preceding discussion it is apparent that to follow trend in vegetation adequately on mountain range-watershed lands it is necessary to periodically assemble information on the density index, floristic composition, and plant vigor. The density index of the desirable forage species is most sensitive to changes caused by grazing use but information on the total plant cover is of value from the viewpoint of watershed protection. Floristic composition is best followed by grouping plant species on the basis of their reaction to grazing use; also including as criteria desirability as forage and value as watershed cover. Vigor is an important criterion of trend and can be followed on an objective basis. Whereas, criteria for evaluating these elements by condition classes may be likened to stair steps; the steps must be much smaller for following trend, in fact, more on the order of an escalator. To do this requires something more than adjective ratings such as good, fair, poor, etc., A means of accomplishing this end is a numerical scale which will at the same time supply a means of summarizing and interpreting collectively the data on all site elements. The Range Condition and Trend score card, as shown later in figure 5, is suggested for this purpose and will be considered in detail.

Ordinarily the administrator is not concerned with soil surfaces completely devoid of vegetation. His major problem is generally in the improvement of the plant cover as measured by greater abundance and increased vigor of desirable species as obtained through management practices.

Rate of change may be greatly influenced by the abundance of competing vegetation. Competition for moisture and light from shrubs and trees may be especially intense and affect both the amount of cover and

the composition. It is for this reason that attention should be focused mainly on the areas least subject to the influence of overstory species and most likely to be grazed by livestock such as the openings within the timber type.

The magnitude and rate of change in vegetation is influenced principally by grazing use and weather. To separate the effects of one from the other is difficult. It requires first of all frank recognition of what the grazing has been and what the weather has been during the period observed. If the weather has been favorable and the grazing use excessive and the various elements for judging vegetation have deteriorated within this interval of time, the change can be attributed to grazing. Conversely, if weather has been droughty and grazing not excessive, the change may be considered as a natural fluctuation with weather. If both weather and grazing use have been variable, as so often happens, a dilemma occurs as to the causative agent, which can be solved only through further observation. It is important, therefore, to determine the principal causative agent causing the change in order that proper corrective action may be taken in management. Fenced plots and lightly utilized portions of the range are distinct aids in separating the effects of grazing use from weather.

The frequency with which a range is intensively examined to determine a significant trend will depend on the magnitude of change to be expected (and the administrative urgency for accomplishment of the work). Since weather cannot be controlled, the magnitude of change will depend on the plant community concerned and whatever has been done in the way of management to bring about a change. If we assume that a change of 20 percent in any one element is significant, then changes are known to occur

fairly rapidly, within 1 to 3 years, in the semidesert grassland, shortgrass and sagebrush-grass types, as shown in tables 1, 2, 3, 7, and 9.

Information on the magnitude and rate of change that can be expected on mountain range types is largely lacking. It is believed, however, that because of less fluctuation in moisture the changes resulting from weather alone are less abrupt and of smaller year to year magnitude (as indicated by the data in tables 4 and 12), than the changes which occur at the lower elevations. Accordingly, measurable and significant changes will not occur within a year's time but at a minimum of 2 to 6 years. This is borne out by critical observation of the many fenced exclosures in mountain range types which have been built within the National forests. If such changes were plotted on a graph as they occur, it would require three or more points to show a definite trend, especially if there were extreme drought years within the period shown. The significance of all this to the administrator is that measurements need not, ordinarily, be taken more frequently than every other year. In order to follow trend effectively for management purposes, the method must be sufficiently sensitive that it will record the actual change and not be merely a recording of apparent changes (as shown in the case of density table 12), which may arise through personal error or bias in measurement.

Soil Condition--Elements to Consider in Trend

Soil formation and development are dependent upon the factors of environment such as: time, climate, cover of vegetation, the nature of the substratum from which the soil is derived, and erosion. Soil and vegetation are interdependent--anything that affects one eventually affects the other. The two together serve to regulate the flow of water from the earth's surface. Consequently, it is as important, since soil is the basic resource, to know what is happening to the soil as it is to the vegetation.

Standards for recognition and classification of soil conditions and types have been developed and are in wide use. However, these criteria for recognizing changing soil condition need modification and simplification for general administrative use. One suggestion that has been made is to develop standards for judging both vegetation and soil condition on a soil-type basis. While this might be undertaken, there are literally hundreds of soil types that are either recognized or now being described on noncultivated land. This confusing array of soil types and terms are apparent to the individual not trained along this line. To attempt to follow the changes on a soil-type basis is much beyond the present state of knowledge for the average administrator. As a greater knowledge of soils is acquired we may ultimately want to set up condition classes on the basis of potential site productivity. One approach to this problem, which has practical possibilities of field application, is that now being taken by Retzer of the Rocky Mountain Station. About a dozen broad soil groupings are made, largely on the basis of geological origin, and rated accordingly as to fertility and erosion characteristics. In the light of present knowledge soil condition and trend seems to be centered around several factors--fertility, infiltration and water holding capacity, and erosion rates.

Soil Fertility--As a Measure of Trend

Soils (31) are composed of solid, liquid, and gaseous materials. The solids are made up of particles of mostly mineral matter (except soils such as peat) mainly the highly insoluble silicate minerals, iron and aluminum. In tropical soils the silicates are leached away, leaving iron and aluminum compounds. whereas in the northern climates silica is left after leaching. Other elements essential to plant life include

phosphorus, calcium, potassium, oxygen, nitrogen, sulphur, and copper, and occur in varying quantities. Chemical, physical, and biological properties of soil are dependent on the surface activity of the clay fraction. Sand and silt are only skeletons of soil, whereas clay and humus are the active portions. If clay and humus are removed by erosion the ability of the soil to produce is greatly reduced. The difference between a productive soil and an unproductive soil does not consist of the total concentration of the soil solution but in the recuperative power of the soil to replace its original strength of nitrates, phosphates, sulphates, etc., during active plant growth and following the removal of a crop such as forage. Furthermore, there is a large variation within the same soil as to its content of available plant food materials. Some soils also are naturally deficient in essential elements such as phosphorus and calcium. While these elements may show up in a chemical analysis, they may not be available to the plant because they may be closely tied up in a nonavailable form. It is for these reasons that a single chemical analysis is not too indicative of soil fertility. It is also for these reasons that it is not possible for the average range administrator, at least, to rate soils as to fertility level by ocular means. Since analyses are expensive and ocular ratings of fertility inexact, their use in following the trend in fertility must be considered impractical for general administrative application.

Infiltration and Water-Holding Capacity
—As a Measure of Trend

Infiltration is the process by which water enters a soil at the immediate surface. In other words, infiltration rate is indicated by the amount of water that doesn't run off, consequently, surface runoff is good indication of infiltration capacity. Maintenance of the infiltration rate at

an optimum level is important in preventing accelerated erosion, attaining maximum forage production and maintaining good watershed conditions.

The infiltration rate is generally measured on small plots by means of an apparatus known as the infiltrometer by which water is applied in a form to simulate natural rainfall. Sampling is tedious, requires technical skill and cumbersome equipment. A rough index of the infiltration rate may be obtained by the use of iron rings or open-ended tin cans into which a measured quantity of water is poured and the time required for absorption recorded. This simple method has value mainly [only] for demonstration purposes.

Infiltration rate and water-holding capacity varies greatly with soil texture and structure. Condition of vegetation influences the rate of infiltration on soils derived from basalt, rhyolite, quartzite, diorite, limestone, shales, and some granites. It is influenced only slightly, if at all, on soils which originate from sandstone and schist. Hence, as a measure of trend on these latter soils, the infiltration rate has small value as a measure of condition even if a practical means for its determination were available.

It is also true that the soil fauna are most abundant in soils that have a good cover of vegetation. New Zealand. They in turn play an important role in the development of soil structure which influences infiltration.

On those soils where the infiltration rate is dependent on the vegetation conditions, grazing animals have an important influence, mainly through compaction of the soil by trampling and reduction of surface cover of vegetation by grazing. Soil structure also plays an important role in determining water and air relations within the root zone. From a practical point of view any evaluation of soil structure,

particularly with respect to aggregation and porosity, aids in diagnosing and correcting troubles encountered in producing vegetation. Water relationships of the soil depend on the amount and nature of the pore spaces present, condition of the surface layer, and the soil moisture content at the time rainfall occurs. Condition may be classified as good or bad on the stability and porosity of the soil granules.

The percolation rate of water into and through each horizon also is an important consideration. A soil only takes water as fast as the slowest layer and if, for example, that is just below the surface, then it will cause heavy runoff.

The most important factor in preventing runoff from any given storm relates to the ability of the soil to take in water as fast as it falls. From a hydrological point of view the condition of the surface (porosity) and the moisture content at the time of the storm are the important physical conditions affecting infiltration rates. As pointed out by Kellogg (25), "In general the more serious erosion injuries to soil are not chemical, not the loss of plant nutrients, but the change in structure, the loss of crumblike surface horizons and the exposure of massive clays, hardpans or even solid rock." Whenever soil surfaces are bared the falling rain drop has the impact of a miniature bomb, splashing the finer soil particles into the larger pore spaces thereby sealing the surface pores and reducing the infiltration rate.

<u>Litter and its influence</u>.—Aside from living plants, the amount of litter, mulch, or dead vegetation matter has important influences. These are mainly through the reduction of raindrop-splash erosion and its subsequent effect on the penetration of rain water. Dead organic matter also is important in the maintenance of soil structure. Organic acids

Short grass
middle –
'semi-desert
grassland'

aid in the beneficial aggregation of soil particles. Because of these influences, and since the direct determination of infiltration rate is difficult, the periodic measurement of litter is important for following soil trends, particularly on mountain-range watersheds.

The rate of accumulation of forage-plant litter is influenced by the degree of utilization, climate, and periodicity of fires. It also varies with the plant species. For example, in the shortgrass vegetation of the Great Plains, Weaver (49) observed a good soil mulch prior (1928-1933) to the great drought. During seven subsequent drought years no litter was found on the bare, black soil but with the return of better rainfall years restoration of a protective cover of plant debris took place. Every plant species contributed to this process but it varied. Among the more efficient were Junegrass, prairie dropseed, bluegrass, blue grama, sideoats grama, hairy grama, and among the less efficient were needlegrass and western wheatgrass. On mountain range lands litter accumulation is more rapid with grass vegetation than with weeds such as dandelion. In the measurement of litter for following trend two things are of importance--coverage and depth. Amount of coverage between living plants is the more important criterion because litter 1/2-inch deep is as effective or nearly so as deeper amounts in its effect on infiltration rate.

Erosion Rates or Soil Stability --As a Measure of Trend

To fully appreciate the importance of soil stability one must first understand something about soil formation. Mature soil is composed of layers of accumulated materials, formed from rock weathering by water, air, temperature, and organic life. Soils are generally classed as: (1) Primary or residual soils that are formed in place through aeons of weathering and leaching of the parent material, (2) secondary soils formed

by transported material such as the alluvial soils of a mountain valley or the wind-drifted loessal soils.

Soil layers vary in color, texture, and structure, and make up what is known as the soil profile. In general three major layers, designated as horizons A, B, and C are recognized. The upper layer, horizon A (a zone of leaching), usually a thin darker-colored stratum, relatively lighter textured, open and friable, allows ready penetration of water and retards loss of moisture from horizon B directly below. The latter is a layer of accumulation of clays, organic colloids, and acids made up from finer particles brought down from above and a matrix of materials from below. Horizon C is the partially weathered substratum which in the case of primary soils is weathered rock and in secondary soils may be sand, clay, or rock.

If at any time erosion exceeds the rate of soil development then erosion is definitely accelerated. Whenever horizon A has been removed through accelerated erosion the ability of the soil to absorb water and air is reduced, forage production is low, and grazing capacity is decreased. Sinclair and Sampson (44) found that growth was most rapid and flower production earlier in A horizon soil than in the B or C horizons. Furthermore, the perennial grass species (Danthonia Californica, Stipa pulchra), used in the study failed to produce seed when grown in the lower horizons, indicating inability of these desirable plants to complete a normal growth cycle under poor soil conditions.

Immature soils which are common on mountain lands, do not have well defined profile layers and their characteristics are greatly influenced by the parent material. For example: shales produce sticky clays, coarse sandstones produce sandy soils, and granites produce coarse soils.

Accelerated erosion is loss of soil at a rate exceeding soil formation. It is generally characterized by one or more of the following happenings:

1. Loose stones, rock, or gravel cover the surface forming an erosional pavement. (A common occurrence on desert areas).
2. Rock fragments raised on pedestals. Vegetation growing on stools or conversely covered by soil and debris. (Pedestals may be a deceiving indicator of soil loss when frost heaving is common).
3. Drifting soil, blow sand, and dunes.
4. Recent gullies, including channels and rills which have cut through the upper soil horizon.
5. Sheet erosion—the removal of soil in thin sheets, the least conspicuous and most insidious type of erosion.

These are the earmarks of accelerated erosion. Their measurement by present known field methods has been inexact and unsatisfactory. Their use as an indicator of trend, particularly in attempting to correlate present erosion with present grazing use is especially difficult. For example, in the most advanced stages of sheet erosion, wherever a complete erosion pavement has been formed, current soil loss may be small. However, as pointed out by Talbot (46), in general, a distinct increase in numbers of recent gullies certainly indicates a "slipping range" and failure of vegetation to reclaim small gullies resulting from past abuse is a hint that recuperation has not begun. Kellogg (26) concluded that some of the least conspicuous erosion is often the most harmful, and that adequate criteria for recognizing accelerated erosion in the field have yet to be developed.

Although the spectacular forms of erosion such as rills and gullies are difficult to measure, their general progress can be recorded by

photographic means. An index to the less conspicuous types of erosion can be obtained by observing periodically the changes in the "erosion hazard." The erosion hazard of any soil decreases as the amount of ground cover increases. "Cover" insofar as soil protection from raindrop splash erosion and subsequent transportation of the soil particles at an accelerated rate includes many things. Ground cover includes not only forage plants, but other plants as well, including club mosses, and in addition litter, erosional pavement, and rock. Each of these items can be measured so that their sum total represents the degree of soil protection. A convenient scale, developed by Elbert Reid and co-workers for a study conducted in 1950 on the Roosevelt National Forest in Colorado is as follows:

0-7 percent bare soil = no erosion hazard
8-24 " " " = slight erosion hazard
25-50 " " " = moderate erosion hazard
51+ " " " = severe erosion hazard

It is not known how widely this scale is applicable because of the wide difference in erodibility of different soils. However, until experience proves otherwise, it merits adoption since the figures are subject to easy modification particularly if the basic information on the ground cover is maintained.

Significant Findings--As Related to Measurement of Trend

It is apparent from the preceding discussion on soils that there are a number of limitations for collecting specific information on trend of several important factors including fertility and infiltration rate. However, the efficiency of these factors depends directly on soil stability and objective data can be obtained on this factor. This includes collecting information periodically on: the amount of ground cover as related

to erosion hazard, the character of current erosion on the slopes and drainages, and an appraisal of the soil as to current permeability to water. As in the case of vegetation condition, the range condition and trend score card, figure 6, forms a good administrative tool for accomplishing this end, in that it is an aid to summarization and interpretation of the data in numerical terms.

DEVELOPMENT OF 3-STEP METHOD FOR MEASURING TREND

As set forth in the working plan (34) of the condition and trend study, the primary objective is to uncover, adapt, or develop a method or methods for the determination and measurement of trend in condition of western National forest ranges. As the first step in meeting this objective, a major part of the author's field time during 1948 was spent in considering with personnel in range research and administration, the various methods available for measuring trend in range condition. All methods considered were discussed and actually demonstrated in the field. Especial attention was focused on methods of measuring vegetation as well as other site factors which in the opinion of regional and station technicians possessed worthy attributes such as accuracy, simplicity, and applicability on a range unit basis. As the second step in a procedure a summary (35) was prepared indicating the major features of the methods available for measuring or appraising the various elements which must be considered in following trend and appraising condition.

As an outcome of this summarization it was decided that no single method warranted western wide testing. Furthermore none had been wholeheartedly recommended for such testing by any of the regions or stations. It was apparent that a method combining the most desirable features of other methods would have to be developed. Also, it seemed desirable

that there should, if possible, be complete standardization, with provision for whatever refinements or adaptations as might be necessary to meet particular regional needs.

It was further decided that the most pressing current need was for a method or methods that could be used for following trend on perennial grasslands and open timber stands. This selection was made because of the over all importance of these types for water and timber as well as for grazing use, including both domestic livestock and wildlife. It is the grasslands and openings in the timber where grazing use, especially by cattle, is likely to be most heavy.

All regions and stations were in accord that to follow trend most efficiently and effectively on a range-unit basis, permanently located open-range plots, transects or "bench marks" must be established within the allotment. Trend would be determined by repeated measurement of these plots at periodic intervals. Accordingly, the most logical approach toward solution of the problem of developing a method was to determine how the information on vegetation and soils should be obtained at each of these permanently located sampling sites. It was the consensus of opinion that the method for following trend must, wherever possible, actually measure with a high degree of accuracy each factor of the site in order to furnish incontestable information for use in management. Some of the factors for judging trend on these sites, such as the density index and floristic composition, could be measured with a reasonable degree of accuracy. Other factors, such as loss of soil, have to be recorded largely in descriptive terms. Both types of information are essential for a complete picture of trend. In addition to this requirement, the method to be developed must

be simple, reliable, rapid, require a minimum of equipment, and the information obtained should be easily summarized and interpreted. It must form a workable tool that could and would be used by the ranger. Accordingly, joint field work, with both research and administration participating, during 1949 and 1950 was devoted to the development of a method, testing it as to its accuracy and reliability and ascertaining the optimum number of sampling units required for measuring condition and trend. The method evolved and tested is designated at the 3-Step Method. Preliminary findings (36) were reported in 1950.

The 3-Step Method

The 3-Step Method incorporates the best features of several measurement methods. As the name implies, it consists of three steps. Step one is an adaption of the New Zealand Pinpoint method (similar to Ellison's point analyzer and the Southwestern frequency-point methods) and the line intercept (8). Step two is based on methodology involved in the use of the Southwestern Range Condition and Trend Score Card (38). Step three is derived from the photo-transect method of the Intermountain region.

The "3-Step Method" upon which two years of field work was centered is described specifically as follows:

Step one

Step one consists simply in the establishment of a permanent transect line and its measurement by means of the modified frequency point or loop method.

In the establishment of the transect line, a metal tape 100 feet long is stretched as tightly, as straightly, and as closely as possible to the soil surface. Where an abrupt change in slope occurs as across a small drainage or depression, it may be

necessary to fasten this part of the tape to the ground in order to have the transect line conform with the topography. With the tape in place three permanent angle iron stakes are driven along the same side of the tape, with one flange of each stake parallel with the tape at 0.0, 50.5, and 99.5 foot marks. Placement of the stakes at these points avoids interference with the loop readings. In remeasuring the line at some future date, the examiner should be careful to so stretch the tape that the flanges of the stakes are parallel to one edge and that the iron stakes coincide with the same foot marks. A heavy engineer's tape 1/8 to 1/4 inch wide, which has chaining pin notches at the foot marks appears to be most suitable (i.e. Keufel and Esser No. 7679). In some situations, such as narrow stringer meadows or dense shrub types, shorter length lines 50 or even 25 feet long are preferred to the 100 foot length, because of greater ease in establishment and greater facility in re-location and remeasurement.

Each site selected for sampling will have two or more transects placed in a cluster. Guides to the optimum number of transect clusters and reasons for this type of sampling are discussed in section "Application on an Allotment Basis."

In the measurement of the transect line, 100 observations (at 1 foot intervals in the case of a 100-foot transect) are made at mechanical intervals along the edge of the tape which is adjacent to and parallel with the angle iron stakes. Each observation (beginning with the one-foot mark on 100-foot transects) is made by means of a 3/4 inch diameter ring or wire loop attached

to a long shank (figure 2). The latter is for convenience in holding and for plumbing from the tape whenever the tape is above the ground surface. Each observation within the loop is recorded on a form such as that shown in figure 3 as perennial vegetation, litter, rock, pavement, or bare soil. To simplify recording standard symbols are used for species, "M" for moss, "R" for rock, "P" for pavement, "L" for litter, and a dash for bare soil.

Perennial grasses and weeds must have the root crown or a portion thereof within the ring in order to be recorded as an observation. Crown spread is ignored in order to eliminate differences which would otherwise arise from utilization or current plant development. In rare cases, two or even three plants of different species may occur within the same loop in which event all species are recorded. Similarly, with browse species, only the perennial portion of the crown is considered, current annual twig growth on the outer periphery of the crown being ignored. Annuals are recorded as a simple dot tally at the bottom of the form. Seedlings of perennials, not as yet definitely established, are likewise recorded.

In the event there is no perennial vegetation within the loop, a decision must be made as to what dominates or characterizes the loop. For example, if over half the loop is covered with litter, it is recorded as such. If the loop is less than half occupied by litter, as with a few occasional grass stems or pine needles, it is recorded as bare soil, or rock (rocks exceeding 3/4 inch diameter) or erosional pavement (Pebbles 1/4 to 3/4 inch diameter). Mosses

K-1291, K1292

Figure 2.—Illustrating Step One (of the 3-Step Method) - the loop method of measuring vegetation, litter, and bare soil. Upper photo—one man makes the readings and records the data. Lower photo—closeup of wire loop, showing an observation on perennial grass.

RECORD OF PERMANENT LINE TRANSECT

Cluster No. ______

Allotment ______________ Date __________ By ______________ Transect No. ______

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	69	80
81	82	83	84	85	85	87	88	89	90
91	92	93	94	95	96	97	98	99	100

BARE SOIL ______
PAVEMENT ______
ROCK ______
LITTER ______
MOSS ______
FORAGE DENSITY ______
OVERSTORY ______
UNDERSTORY ______
PLANT COVER ______
GROUND COVER ______

SPECIES
(List by name and symbol)

KEY INDICATOR SPECIES NOT RECORDED

VIGOR MEASUREMENTS

Species	Species	Species
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

NOTE: List overstory species at top of each block.
L = Litter; R = Rock; P = Pavement; M = Moss;
Dash = Soil

DOT CHECK:

Perennial Seedlings Annuals

Total ______
Avg. Max. ______

Figure 3.—Form for recording information obtained in Step One.

growing in the soil are observed in the case of litter. Annuals, if sufficiently abundant in the basal parts to dominate the ring, are listed as litter in addition to being recorded in the dot tally. Rodent activity, such as gopher casts or diggings may be recorded as such if it seems desirable. But the observations are treated in the marginal summary as bare soil, pavement, etc., whichever the case may be. Wherever two storied vegetation is encountered, as with sagebrush, overstory vegetation and understory elements encountered directly below are both recorded.

The margin of the form is used for summarizing the 100observations. The number of hits on bare soil, pavement, rock, and litter are counted and their totals recorded. Forage density is the total of all the squares where either desirable or intermediate species occur. This may exceed the number of squares in which vegetation is observed when more than one species is recorded within the same loop. Plant cover is the total of all squares with perennial vegetation excluding plants directly beneath the overstory whenever shrubs occur. Ground cover is computed as 100 minus the total hits on bare soil. The total number of hits for each species is also summarized.

The 100-foot transect is visualized as sampling a plot 50x150 feet. Since it is only one sample unit comprised of 100 observations, there may be species within this plot that were not encountered on the line transect. Such species may be the remnants of a former bunchgrass cover or they may be undesirable invaders such as cheatgrass or tarweed which are just beginning to make an appearance in the composition. Additional transects to pick up

these usually rare species are not warranted because of the additional time required in measurement, these unrecorded species are simply listed as being present within the plot under the heading "Key Indicator Species Not Recorded."

Measurement of vigor is made by measuring the maximum leaf length or maximum flower stalk height of the most important desirable species. Plants which are measured are selected by random pacing along the transect and within the plot. The examiner should avail himself of all comparisons on vigor as with plants lightly grazed but within the protection of rocks, or plants growing in ungrazed enclosures. Criteria for judging vigor have been developed in a few regions for several key species. These standards should be used as a guide to rating vigor, whenever available.

Step Two

Consists in the summarization of transect and plot observations directly in the field, on the site where the information was collected. Summarized data for all transects within the cluster is transferred to the transect cluster summary form shown in figure 4. Percentage composition for each species and each group of species is figured on the basis of total number of hits. Where the composition is simple, percentage composition need not be computed as the average number of hits will suffice for interpretation by the score card. Following this transfer and summarization for all transects--the data are now ready for interpretation.

TRANSECT CLUSTER SUMMARY AND CURRENT RANGE CONDITION AND TREND RATING

Allotment ______________________ District __________ Cluster No. ______

Date __________ By ________________________________ No. Transects ______

DESIRABLE	Total Hits	Avg.	INTERMEDIATE	Total Hits	Avg.	UNDESIRABLE	Total Hits	Avg.
Total			Total			Total		

SUMMARY OF ALL TRANSECTS IN CLUSTER

	Transect No. 1 Hits	2 Hits	3 Hits	Avg.
Bare Soil				
Erosion pavement				
Litter				
Rock				
Forage density				
Plant cover				
Ground cover				

CONDITION AND TREND RATINGS OF CLUSTER

VEGETATION

Forage Density __________

Composition __________

Vigor __________

Total __________

Condition class __________

Current Trend Up ___ Down ___ Static ___

Soil

Erosion hazard __________

Erosion stage __________

Profile __________

Total __________

Condition class __________

Figure 4.--Form for summarizing transect cluster data and rating condition and ratings obtained in Step Two.

Interpretation of the data is made by means of criteria presented in score card form; such as shown in figures 5 and 6. The final summary is thus the numerical ratings for the major elements of vegetation and soil. It is these numerical ratings which form the final record for future comparison with subsequent records for the determination of trend. Whenever criteria are available a record is also made of the apparent current trend.

Step Three

Consists of two key photographs (figure 7) which form a visual record, in part at least, of the elements measured and observed in Step One. The camera is set up directly over the 0.0 foot mark and two photos are taken:

1. A general type photograph, taken from one end of the permanently located transect line with the other end stake centered in the background. This photograph is necessary for showing general changes, whenever the photo is repeated, which may take place in the aspect of the type. It is also a helpful aid in relocation of the sampling area.

2. Closeup of a 3x3 plot taken obliquely and taken from the same photo point as the general photo. The plot is delineated by means of rods or by two six-foot folding carpenter rules. It is centered on the transect line with the nearest side of the plot located 3.5 feet from the photo point. The close-up photo forms a good record of plant cover and often reveals movement of soil and other changes whenever repeated.

If deemed desirable, additional photographs (figure 7) may be taken from the same photo point or other established photo

*TENTATIVE CONDITION STANDARDS - MONTANA MOUNTAIN GRASSLANDS

SCORE CARD RATINGS FOR VEGETATION

Forage Density Index

55 to 65 hits = 10-9, 45 to 54 hits = 8-7, 35 to 44 hits = 6-5, 20 to 34 hits = 4-3, 19 to 0 hits = 2-0

Composition

**Desirable perennial grasses, weeds, shrubs make up 70 percent of plant cover. *Festuca scabrella* conspicuous 10 percent or more of composition.	13-15
Desirable perennials dominant (50 to 69%). *Festuca scabrella* (may be absent) forms less than 10 percent of the vegetation. .	9-12
Desirable perennials 30-49% and with less desirable perennials make up over 60 percent of the composition.	6-8
Desirable perennials 5-29%; less desirable perennials more abundant than desirables; collectively they make up from 35 to 60 percent of the composition	3-5
Desirable perennials less than 5%; low value undesirable species make up at least 65 percent of the cover.	0-2

Vigor of desirable species - based on leaf length and growth form (criteria for summer of 1950 only)

Festuca scabrella

Leaves 16"+	= 9-10
Leaves 12-15.9"	= 7-8
Leaves 10-11.9"	= 5-6
Leaves 8-9.9"	= 3-4
Leaves less than 8"	= 0-2

Festuca idahoensis

Leaves 6"+	= 9-10
Leaves 5-5.9"	= 7-8
Leaves 4-4.9"	= 5-6
Leaves 3-3.9"	= 3-4
Leaves less than 3"	= 0-2

Interpretation of forage condition score

Excellent (30 to 35)
Good (25 to 29)
Fair (20 to 24)
Poor (15 to 19)
Very poor (14 to 0)

*Developed on Lewis & Clark National Forest, 1950, in connection with Range Condition and Trend Study.

**See attached species list.

Figure 5.--Condition standards for vegetation assembled in score card form for use in interpretation of data from transect clusters and to rate forage condition when delineating class boundaries in mapping condition.

Species List for Montana Mountain Grasslands

Desirable	Intermediate	Undesirable
Fsc - Festuca scabrella	Ahi - Agrostis hiemalus	GEU - Geum spp.
Fid - F. idahoensis	Pse - Poa secunda	CLE - Clematis spp.
Fov - F. ovina	Ppr - P. pratensis	VIO - Violet spp.
Cca - Calamagrostis canadensis	Msq - Muhlenbergis squarrosa	TAR - Taraxacum spp.
Asp - Agropyron spicatum		AST - Aster spp.
Asu - A. subsecundum	Kcr - Koleria cristata	SOL - Solidago spp.
Asm - A. smithi	GER - Geranium spp.	ANT - Antennaria spp.
AGR - Agropyron spp.	CAST - Castilleja spp.	Afo - Arnica foliosa
CX - Carex spp.	TRI - Trifolium spp.	LUP - Lupine spp.
Dun - Danthonia unispicata	AGO - Agoseris spp.	ARE - Arenaria spp.
Din - D. intermedia	Ala - Achillea lanulosa	Bte - Bromus tectorum
STI - Stipa spp. (small needlegrass)	Bsa - Balsamorhiza sagittata	Afr - Artemisia frigida
		Agn - A. gnaphalodes
	O - Other	Atr - A. tridentata

CONDITION STANDARDS - SOUTHWESTERN REGION
SCORE CARD RATINGS FOR SOIL

Erosion Hazard Index (Rate from 0 to 15; number of hits is 100 minus bare soil)

90-100 hits = 14-15, 64-76 hits = 10-11, 37-49 hits = 6-7, 10-23 hits = 2-3
77-89 hits = 12-13, 50-63 hits = 8-9, 24-36 hits = 4-5, 0-9 hits = 0-1

Current Erosion - Slopes and Drainages (Rate from 0 to 15)

No apparent erosion or evidence of soil disturbance.	13-15
Less than 25% of top soil removed. No rills present. No active gullies. Old gullies, if present, becoming stabilized	10-13
25 to 75% of top soil removed; or rills often present, occasional* shallow, active gullies; or slight (1 to 2") deposition of sand or eroded material on vegetation or top soil	7-9
More than 75% of top soil but less than 25% of subsoil removed, or frequent shallow active gullies and occasional deep gullies; or heavy (2 to 4") deposits of sand or eroded material.	4-6
Over 25% of subsoil gone; or frequent active deep gullies; or severe (over 4") deposition	0-3

Permeability to Water (Rate each of the following 3 items to total 0 to 15)

Aggregation at surface:	
Crumb structure.	4-5
Soil aggregated but aggregates small (pin-head size)	2-3
Soil fine, not aggregated.	0-1
Compaction of surface:	
Loose and friable.	4-5
Loose but shows evidence of raindrop erosion by thin soil crusts or mud spots on vegetation.	2-3
Hard and compact; resists scraping	0-1
Infiltration and percolation:	
Infiltration and percolation rate high, as shown by abundant organic material and loose (coarse) surface texture	4-5
Condition intermediate between above and below	2-3
Water movement limited as indicated by little or no organic matter, heavy surface texture, surface rain crust, small rocks on pedestals, or an impervious layer close to the surface	0-1

Interpretation of soil score

Excellent	40+		
Good	30-39	Poor	10-19
Fair	20-29	Very poor	0-9

*Occasional = less than 30 percent of drainways are gullies.
Frequent = more than 30 percent of drainways are gullies.
Shallow = gullies whose channels do not cut into subsoil.
Deep = gullies whose channels cut into subsoil or parent material.

Figure 6.—Condition standards for soil, assembled in score card form for use in interpretation of data from transects and for rating site when delineating class boundaries in mapping of forage condition.

W.O. #461118, 461117, 461019

Figure 7.--Upper two photos: Step Three of the 3-Step Method consists of a general type photo and an oblique closeup of a 3x3 plot taken from one end of the transect line. Mountain meadow type, Flagtail Allotment, Malheur National Forest.

Lower photo: Noteworthy happenings can also be recorded by supplementing photograph taken from the transect photo point, such as the beginning of a gulley indicated by "A" and the advent of sagebrush colonies shown here as "B." Flagstaff Allotment, Lewis & Clark National Forest, Montana.

points for recording special situations such as hedged browse and erosional features.

Initial photographs and retakes, although a one-man-job, require special training and aptitude.

<u>Sensitivity and Reliability of the 3-Step Method</u>

Prior to a consideration of how the 3-Step Method may be applied on an allotment basis, it seems logical to consider first its sensitivity and reliability. The soundness of the last two steps of the method is considered to have been adequately demonstrated during the past several years. Step two, which requires interpretation of the summarized transect data by means of range condition and trend score cards was originally developed and tested in the Southwest. There it has been adopted by Administration for use on all National Forests within the region. Similar score cards have been devised and are in varying degrees of use in other western regions. Although data may be carefully obtained from transects, there still remains danger in faulty interpretation because of personal bias and poorly designed score cards. In spite of this danger, the score card method appears to be the most logical means for proper interpretation of data because it forces the examiner at the time of field examination to consider the present status of all important site characteristics. The numerical ratings obtained also avoid the "stair step" grades which must be assigned with purely adjective ratings so that the examiner can with reason grade condition within a condition class and without hesitancy grade the condition in borderline cases where the condition is not clearcut, as for example, between good and fair. A major reason for the failure of many administrative studies has been lack of summarization and interpretation of data, long regarded as an office

job for spare time hours which seldom arise. Summarization and interpretation of the data by Step Two directly in the field avoids this pitfall. Furthermore, even though the condition standards may change as we secure more adequate criteria, the history of the site as obtained in Step One, if properly recorded, is always available for future re-analysis.

Experience with the photo-transect method in the Intermountain region indicates the general photo and the oblique closeup, as obtained in Step Three, to be the most suitable for showing changes in condition. Repeat photographs can be deceiving as to indicated change. For example, a photograph taken before the onset of plant growth may show a considerable difference if repeated even in the same year but later in the season. It is for this reason that photographs should be repeated at about the same time in the season as the original. Another pitfall in repeat photographs is in their use for showing soil loss, such as shown in "A" of the lower photo of figure 7. This same photo, if repeated 10 years later, might show the cutting as having healed over and yet sheet erosion might still be continuing apace.

Major consideration of the sensitivity and reliability of the 3-Step-Method most logically centers around Step One by which the initial site data are collected. Previously made tests on Step One have been reported (36). There in are included information on the: Origin of the "modified frequency point" or "loop method"; how the data on density index and composition compared with that obtained by other methods; where and how it was tested; the magnitude of differences arising from line replacement and between different men making the measurements; and sensitivity of the method in recording change. The advantages of the loop method were reported as follows:

Results of the 1949 field tests indicate the loop method to have much promise as an administrative tool for securing information on trends in range vegetation. It is simple, readily understood, and men can be easily trained in its use. It provides reasonably accurate indices of density of vegetation, floristic composition, amount of litter as it occurs between plants, bare soil and exposed rock. Equipment required is extremely simple. The measurements may be obtained by one man within a reasonable period of time. Data obtained are readily interpreted and are subject to statistical analysis if that appears desirable at any time. Differences between men (as well as differences resulting from line replacement) in many of the 1949 trials were not significant, and, where they did occur, were not prohibitive. Additional testing for uniformity between men is probably not necessary. Sensitivity of the method in reflecting wide changes as from one range condition class to another is adequate. Likewise, the method appears to be reasonably sensitive for detecting smaller changes within a condition class, although this would justify some further testing. Accordingly, the method is believed to be technically sound and that it will be met with acceptance and approval of range ecologists.

The limitations of the loop method were pointed out as follows:

The loop method has certain limitations which should be recognized. These limitations may be segregated into two groups: those which can only be overcome or reduced by adoption of proper precautionary measures and those which may be corrected for by further refinement of the method.

First of all, the Loop Method is not a method to be applied without instruction. Careful and thorough field training of personnel must be carried out prior to actual application. The sample obtained is so small that, in order to determine trend, the utmost care and precision must be observed in obtaining the initial and subsequent measurements. Like any other method, plants with unusual growth forms will have to be specifically defined and the definitions carefully adhered to in order to achieve the greatest uniformity between men. Personnel gathering the data must be able to identify or recognize the more important range plant species. If rangers collect the data, they may need assistance and guidance in its analysis and interpretation.

Features of the loop method which should be further investigated in order to achieve necessary refinement include:

1. Additional testing on the sensitivity of the loop method for reflecting minor changes in vegetation. To carry out this evaluation on the magnitude of changes that may be detected will require assembly of certain information. This would be with respect to the magnitude of changes and the rate with which they may occur in the more important range types, as determined by other methods.

2. Loop method readings do not express forage or herbage production. The only indication of this would be in the appraisal of vigor as called for in the check list of Step Two and the reflection of the loop index of dnesity and plant composition on forage production. Information on the trend in herbage or forage production would be of great value.

3. Additional testing is needed in several other important range types not encountered in 1949, including aspen, mountain brush, and the high mountain grassland of the Intermountain region.

4. The index of litter cover tells nothings as to its volume or depth. Information on the latter might be obtained by recording the litter readings in depth classes.

5. The present size (3/4" diameter) of the loop appears adequate for most situations. However, it is possible in special cases that loops of two sizes might be used, including the present size in combination with a larger one to pick up rare but important indicator species. The use of different size plots or "double sampling" is standard practice in the Forest Survey for recording tree seedlings, pole size reproduction, and volume of timber.

6. The present length of transect line is 100 feet. It is not known whether this is the most efficient length of line for sampling. It is possible, too, that lines of shorter length would afford greater accuracy in making the measurements.

7. The possibilities of improvement of equipment in order to secure greater uniformity between men should be followed up. As, for example, improvement of the plumbing quality of the loop and finding a better means for stretching the tape.

8. Exact specifications for staking out transect lines, witness stakes, metal tags for marking the sampling areas, close-up frames for photo-plots, simplified forms for recording all data, etc., should be worked out."

Additional testing was conducted in 1950 mainly to determine further the sensitivity of the loop method for reflecting minor changes in vegetation, its applicability to other range types such as aspen, and to achieve further refinement of the method for greater reliability. The findings on the latter item have been incorporated within the specifications described herein and accordingly will not be discussed.

<u>Sensitivity of Step One</u>

The loop method described in Step One is essentially a compromise between frequency and area-estimate methods. This was done deliberately

in order to make the method as objective as possible, in other words to make it so simple that the decision of the examiner is insofar as possible one of two alternates--as between black and white. The 3/4-inch diameter loop can be regarded as a minute quadrat where plants are listed by frequency. At the same time, however, it is so small that from a practical viewpoint it also approaches a mere point. Much the same thinking lies behind the use of much larger observation plots. Heddle (23) used frames 6 inches square, which were thrown out at random 100 times on an area being examined and the species encountered were simply listed. His remarks are of interest: "The smaller the frame and the larger the number of readings taken the more closely does this method approach the quantitative, but if this provision were carried to its logical conclusion, the size of the frame will be ultimately reduced to a point, and the method merges into the point quadrat method (27).

The requirement that the method be sensitive in reflecting changes in condition is of equal or greater importance than securing uniformity between men. (Personal error between men can be reduced by increasing the number of plots or clusters.) Obviously it was not possible during the development of the method to wait a year or more for known changes (i.e. as arising from drought) to take place on the transect lines established in the several regions in connection with the study.

However, as previously reported (36), it is possible on the basis of the same data (collected primarily to determine uniformity between men), to examine this material from the viewpoint of sensitivity of the method. Whenever possible to do so, sampling sites within a range type were deliberately placed in different condition situations. The results of these analyses are presented in table 15. It will be noted that the

Table 15.—Magnitude of differences, for several site factors, that can be detected by the loop method, with confidence at odds of 19 to 1.

Location and range type	Site Factor	Average loop index of density	Magnitude of difference required (±)	Percent change required (±)	Number of lines required
OREGON	Climax grasses				
Pacific bunch-grass	Fair condition	37.95	9.5	25	12
	Hi-Poor condition	10.10	2.8	28	22
	Poor condition	3.05	1.3	42	3
COLORADO	Secondary grasses				
Ponderosa pine-bunchgrass	Good condition	29.2	6.0	20	5
	Fair condition	34.8	2.0	6	8
	Poor condition	35.2	3.0	8	6
CALIFORNIA					
Mountain shrub-incl. sagebrush-grass	Browse	32.3	2.0	6	12
	Litter	28.3	5.0	18	22
MONTANA					
Mountain grassland	Total grasses	41.4	3.5	8	22
WYOMING					
Sagebrush-grass	Browse	27.4	2.0	7	5
	Total grasses	14.2	2.0	14	7
ARIZONA					
Shortgrass-woodland	Total grasses	27.4	4.0	15	6

magnitude of difference that would have to occur before it could be detected with confidence by the loop method is comparatively small in all instances. When placed on the basis of percentage change required, the range is greater.

Although the data utilized in these calculations are for various site factors such as climax grasses, browse, and litter, it is believed that similar relationships would obtain with such elements as rock, moss, and other site factors. For example, the item of "climax grasses" in the three condition situations found in the Pacific bunchgrass type of Oregon would obtain just as well with secondary grasses such as Sandberg bluegrass. This is borne out by the data for secondary grasses (mostly blue grama) in Colorado. This is important because the climax species might be entirely lacking on a range in very poor condition and change in the secondary species would have to be relied upon as a measurement of trend.

It will be noted further in the case of litter determinations (California data) that the magnitude of difference required compares favorably with the other elements. This is important because litter (as with bare soil, rock, and pavement) is in the nature of a subjective estimate ($\pm$50%) of the amount within the loop, whereas perennial vegetation is more of an objective measurement. In the case of perennial vegetation, the examiner makes only the simple decision of--it is or isn't within the loop.

These analyses indicate the loop method to be reasonably sensitive in picking up changes in vegetation and other factors. In order to pick up changes within a condition, the sensitivity will depend on the limits that are set for that particular condition class as defined in

the standards set up for the type. For example, in the Pacific bunchgrass type differences within the poor condition class are readily picked with respect to climax species.

As an additional check on the sensitivity of the loop method, tests were conducted in the subalpine grassland type of Utah in 1950. Deterioration in this community is often characterized by marked increase of sweetsage (Artemisia discolor). This rhizomatous plant is single stemmed in its aerial growth. Each stem is distinct, about 1/8 inch in diameter, and grows unevenly spaced from the rhizomes. They are easily counted. The study plan required the establishment of 12 belt transects within patches of the sweetsage. Each transect was 4 inches wide and 25 feet long and 100 loop observations were made in the center of this belt as to crown and basal occurence of sweetsage. Then the belt transect was divided into six segments and about 20 percent of the sweetsage cut and removed at random within the belt by actual count. The transect was then remeasured by the loop method. The same procedure was followed in further removal of sweetsage at about 20 percent steps up to and including 80 percent removal.

The average percentages for the 12 transects are presented in table 16. It will be noted that the percentage removal determined from

Table 16.--Sensitivity of loop method in reflecting changes in sweetsage population as removed in about 20 percent steps
(Average percentages from 12 transects)

Method	Stages of sweetsage removal 20 Percent	40 Percent	60 Percent	80 Percent	Percent left	Total
Actual count	19.4	38.6	57.9	77.3	22.7	100.0
Basal index-density by loop	20.1	39.6	57.2	79.1	20.9	100.0
Crown index-density by loop	15.7	33.1	53.1	74.8	25.2	100.0

the average basal index of density on the 12 transect lines is very close to that shown by actual count of sweetsage plants. Percentage removal as indicated by the index of crown density is not quite so good but is still fairly close to the actual.

Averages can be misleading as to the accuracy with which a method measures change. However, such was not the case in the sweetsage removal tests. Further analysis of the field data was made by simple regression analyses with additional determination of the confidence limits. Results are shown graphically in figures 8 and 9. Percentage sweetsage removal as determined from the basal index of density is very close to actual. The graph line for this is closely paralleled by the 5 percent confidence bands, and the relationship is nearly linear so that the error for large or small values is not much greater than for intermediate values. This also means that the chances are only 1 in 19 that the mean of a similarly obtained sample (in this case 3 transects) will occur beyond the limits indicated by the confidence bands—either above or below them.

Considering the sweetsage tests, together with the information on sensitivity presented in table 15, the loop method appears to be an adequate method for reflecting changes in density and composition. Known changes that have occurred in several range communities, especially with respect to density and composition have been previously discussed. These changes, as shown in tables 1, 2, 3, 8, and 9 were based on comparisons between grazed and ungrazed range (enclosures) and were determined by methods other than the loop method, largely by chart or list quadrats. The question naturally arises, could they have been picked up by the loop method? The answer is difficult, but one would assume, in the light of the favorable sensitivity tests that the loop method would reflect similar

Crown density

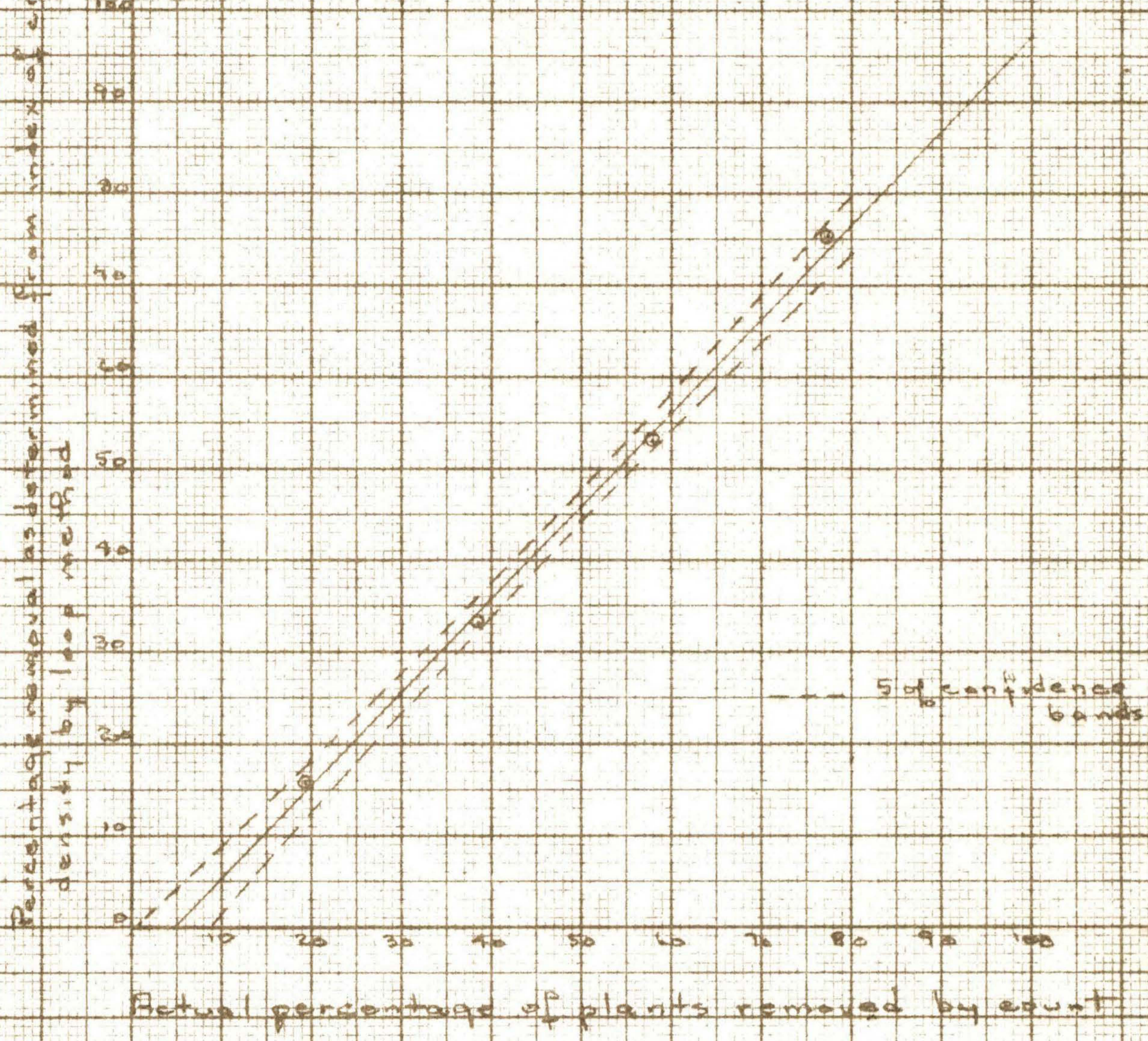


Figure 9. — Percentage removal of sweet sage plants as determined from crown index of density by loop method, with 5 percent confidence bands.

Basal density

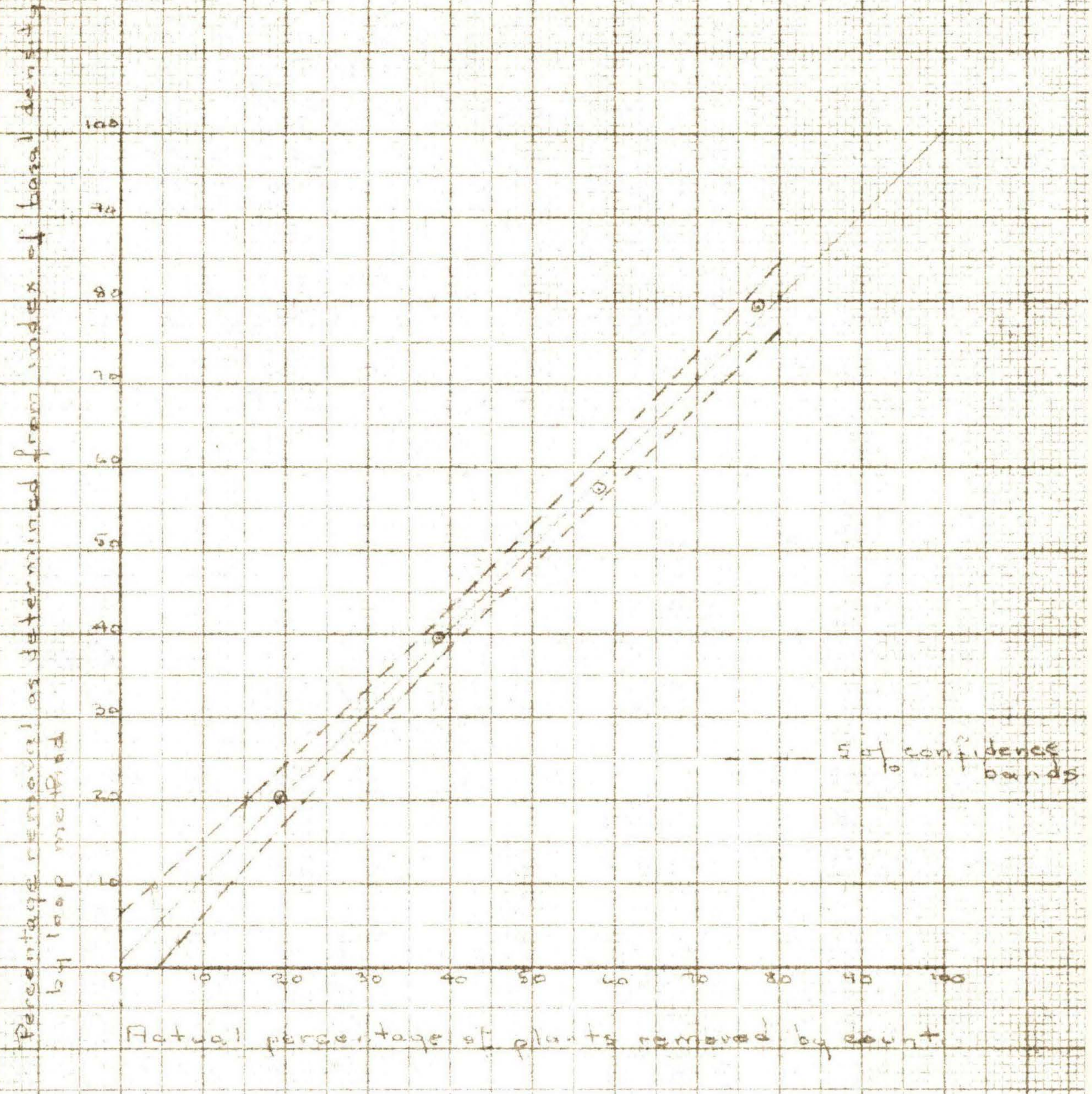


Figure 8. Percentage removal of sweet sage plants as determined from basal index of density by loop method, with 5 percent confidence bands

change. The loop method would unquestionably show the changes listed in table 13 since it is basically similar to Huffaker and Holloway's (24) "minute quadrat" method. Part of the answer is also forthcoming from comparison of the loop method with other methods as previously reported (36).

Comparison of the loop method with the line intercept method which measures actual basal area showed a straight line relationship with very close correlation (r = .9719) between the two methods. Inasmuch as the index of basal density obtained by the line intercept method is very similar to that obtained from charted quadrats, it seems safe to conclude that the loop index relationship would also be linear and closely correlated. Furthermore, as reported by Bauer (6), sampling by the line intercept transect gives decidedly more accurate percentages of coverage than quadrat sampling—probably because the transect has greater linear extent than the quadrat. The loop method does not make a 100 percent appraisal of the vegetation on a transect as in the case of the line transect or charted quadrat. Thus its sensitivity probably increases with increase in the amount of vegetation present. Data obtained from the Flagtail allotment tests in Oregon show that where the basal index of density exceeds 20, the loop method is fairly accurate, whereas in the densities below this, accuracy decreases, especially with respect to composition. This is because the 100 observations taken at mechanical intervals may either miss or hit too much vegetation. This failing can be overcome through increasing the number of lines. As pointed out by Clarke et al (10), the intensity of sampling is an inverse function of the grass cover. Sparse covers require more sampling than those which are dense. (In sparse vegetation the line intercept even with its 100 percent record of the vegetation on the line will likewise show extreme

fluctuation in the composition of the vegetation, which also is overcome by measuring more lines.) Accordingly with a few lines the loop method would reflect the changes shown in tables 2, 5, and 9, where the vegetation is fairly dense; likewise in table 1, where the composition is simple. A greater number of lines would be required in semidesert types with complex vegetation such as indicated in tables 7 and 8. In the areas where changes are shown in square foot density for fairly heavy cover, tables 4, 10, and 12, a small number of lines measured by the loop method would no doubt detect similar changes.

Applicability to Other Range Types

The modified frequency point or loop method was developed originally for grassland vegetation. As previously reported (36) it was tested in a wide variety of range types in various stages of condition. Types included: the Pacific bunchgrass in Oregon, mountain grassland in Montana and California, mixed grama-oak savannah in Arizona, ponderosa pine-bunchgrass in Colorado, big sagebrush-grass in Wyoming and California, wet and dry meadows, bitterbrush and the annual type in California. Similar range types and condition situations were again encountered during the 1950 field season. In Utah especial effort was made to test the method in the aspen type.

Aspen

The aspen type, including the openings, when in good condition, is characterized by lush, tall weeds or forbs up to 4 feet or more in height. It offers a special problem in sampling since the basal area of the forbs is small but the crown spread often forms a complete cover. Two condition situations, good and poor, were each sampled with three transect lines, each 50 feet long. Personal error between four men was not significant.

As shown by the data presented in table 17, percentage composition based on the basal readings does not give as good a picture of the floristic composition as that based on the crown cover. It was most poor on transect 6 where the density index was lowest. On the other hand, the basal readings gave an adequate picture of other site factors whereas the crown readings did not. In the case of transect 4, with a complete crown cover, there is no information on litter, bare ground, etc.

Table 17.--Comparison of crown and basal readings by the loop method in an opening within the aspen type rated in good condition. Summary of three transects

Habitat factor	Transect 4: Crown	Transect 4: Basal	Transect 5: Crown	Transect 5: Basal	Transect 6: Crown	Transect 6: Basal
Composition (in percent)						
Brom	35.3	45.0	34.7	62.0	46.7	83.3
Agur	8.5	10.0	21.4	23.8	13.7	8.3
Osoc	17.0	10.0	21.4	9.5	11.2	8.3
Mertensia spp.	15.2	15.0	6.8	-	6.8	-
Thfe	2.6	-	-	-	-	-
Viam	1.6	5.0	5.9	-	5.8	-
Sambucus spp.	18.1	15.0	7.4	-	-	-
Viguiera spp.	-	-	.5	-	10.4	-
Galium spp.	-	-	.3	4.7	-	-
Heracleum spp.	-	-	-	-	4.2	-
Aster spp.	-	-	-	-	1.0	-
Density index	100.0	20.0	98.0	21.0	97.0	12.0
Litter	0	70.0	1.0	67.0	2.0	64.0
Bare ground	0	9.0	1.0	10.0	1.0	20.0
Gopher activity	0	0	0	1.0	0	3.0
Rock	0	1.0	0	1.0	0	1.0

In the aspen opening in poor condition, table 18, the best picture of composition is also obtained from the crown cover. This is also the case with the data obtained by the point analyzer method (not used in good condition site because equipment is not adapted to tall vegetation). The similarity of readings between the two methods for percentage composition as based on crown cover is striking. This is especially so since

the point analyzer method as applied required 300 observation points as compared to 100 for the loop method. Furthermore, the two methods, although used on the same transect line, do not sample exactly the same population. The point analyzer, samples only vegetation directly beneath the line whereas the loop method takes in plants as far out as 3/4 inch from the line.

Table 18.—Comparison of readings obtained by point analyzer and loop methods on crown and basal portions of plants found within an opening in the aspen rated as in poor condition. Summary of one transect

Habitat factor	Point analyzer		Loop method	
	Crown	Basal	Crown	Basal
Composition (in percent)				
Popr	6.2	40.0	12.0	42.8
Brca	1.8	-	2.8	3.5
Agtr	-	-	.9	-
Taof	51.3	20.0	49.1	25.0
Ruoc	10.6	-	10.2	-
Chal	1.8	-	1.8	7.1
Viml	13.3	20.0	6.5	-
Celi	3.5	20.0	1.8	14.2
Stja	2.7	-	-	-
Rume	2.7	-	2.8	-
Heho	.9	-	2.8	-
Podo	2.7	-	-	
Asod	2.7	-	6.5	3.5
Viam	-	-	.9	-
Density index	37.7	1.7	54.0	14.0
Litter	20.3	34.3	16.0	32.0
Bare ground	41.0	62.3	29.0	53.0
Gopher activity	1.0	1.3	1.0	1.0
Rock	0	.3	0	0

The significance of these findings is that modification in the loop method is necessary for practical application in vegetation made up principally of forbs as is the case in the aspen type. A good picture of the composition could be obtained from the basal readings but it would require a prohibitive number of lines. In forb vegetation it is

suggested that crown readings be utilized for composition and basal readings for density index, litter, bare ground, and rock.

Reseeded Areas

Where the area has been reseeded by broadcasting the seed no especial problems arise in sampling the area by the loop method. However, where the seed has been planted by a drill, the plants will occur in rows which will be the width of the drill spacing. Since loop readings are also made at mechanical intervals it is possible to hit or to miss every drill row depending on the location of the transect stakes. Trials on drilled crested wheatgrass plantings in Utah indicated that this difficulty could be overcome by placing the transect tape at right angles to the drill rows. Then the 100 observations are made with a tape which has had the observation points randomized and marked with paint within each one foot segment. Interpretation of the data should be made from standards especially prepared for judging reseeded areas.

APPLICATION OF 3-STEP METHOD ON AN ALLOTMENT BASIS

Actual application of the 3-Step Method on an allotment basis was carried out during the field season in four regions as outlined in last year's report (36). The areas utilized were as follows: (1) Flagtail allotment, North unit, Malheur National Forest, Oregon, mainly open forest (ponderosa pine), sagebrush-bitterbrush, and mountain meadow. (2) Flagstaff allotment, Lewis and Clark National Forest, Montana, mainly mountain grassland. (3) Harvey Valley allotment, Lassen National Forest, California, mainly dry and wet meadows, bitterbrush, and open forest (Ponderosa pine). (4) Sacaton allotment, Gila National Forest, New Mexico, with open grassland (blue grama) and woodland predominating. Findings and experience gained in making these trials are utilized as the basis for the specifications and instructions herein reported.

Prior to application on a management unit basis it is important to give proper consideration to the following items:

1. Selection of the allotment for analysis and sampling. Eventually all allotments which have important range and watershed values may be sampled. However, with present limited time of personnel for doing the job, it is important that first things come first. For each ranger district, priorities should be set up as to which allotments or management units it is most essential to secure trend data. Such an appraisal should consider: Whether or not the allotment is a source of controversy, whether or not recent or proposed and impending changes have been made in management which can be expected to influence its trend, whether or not the information obtained will be eventually useful elsewhere, and how important are other land values in addition to range. The selection should not necessarily be on the basis of present state of deterioration.
2. Assignment of personnel and designation of responsibility. To insure collection of reliable data men should be well trained and experienced individuals. A 2-men crew is most efficient. One member should be GS-7 or higher and should be given the responsibility of carrying the work through to final completion.
3. Time of year for undertaking field work. The field work should, if possible, be arranged during the time of the growth season when the bulk of the plant species are most easily identified. Times to avoid, if possible, are very early spring or late fall following heavy grazing use. Record should be made as to current weather conditions, as well as for the previous year to answer such questions as: Is the survey being made during severe drought, or in an unusually

good year? Is current plant development early, late, or about average?

Pre-field Office Jobs

Certain pre-field office jobs must be accomplished prior to actual application of the 3-step Method on an allotment basis. These include assembly of maps, equipment, and pertinent reference material, forms, and information which will facilitate the work.

Maps

The best maps available should be used but the work should not be indefinitely postponed for lack of a certain type or quality of map.

The best available map on a scale of one inch equals one mile, or larger, will be used. Aerial photographs on which the ground control has been established are preferred for the field work. If aerial photographs are not available, planimetric maps or good topographic maps can be used. When available, aerial photographs can be used as a guide for sketching type and condition lines on planimetric maps. Greater accuracy will be obtained if the type boundaries are mapped directly on the photographs and then later projected onto a planimetric map.

All essential data should be entered insofar as possible. This should include sketching type lines on a broad plant community basis from existing range survey maps. Other essential data include: allotment and management unit boundaries, fences, stock waters, closed areas, etc.

Equipment

Equipment to be assembled includes: 100-foot steel surveying tape, Jacob staff and compass, 3/4-inch loop or ring for making readings, three pins or 18-inch-long screw drivers for stretching tape, heavy

hammer or iron mall, tags or stencils for numbering transect stakes, angle iron stakes for marking permanent line transects, and witness posts for cluster locations. Stakes should be of several lengths--12, 18, and 30 inches for use in different depth soils and are best painted orange.

For the photographs required in step 3, equipment and supplies should include: Camera (i.e. 4x5 Crown Graphic is recommended), tripod, film (preferably speed 50), notebook for recording pertinent notes on photographs taken, and two 6-foot-long folding carpenter rules for marking the close-up photo plot.

Reference Material, Forms, Etc.

Essential reference material includes: Instructions for doing the field work, standards for judging various range types to be encountered, and plant check-symbol lists. A supply of forms, such as shown in figures 3 and 4, for recording, summarizing, and condition criteria in Score Card form for interpreting transect data, together with tatum holders, should be on hand.

Field Procedure in Application of 3-Step Method

Field procedure in application of the 3-Step Method consists of preliminary mapping, installation of transect clusters and final field check of maps, and assignment of condition and trend ratings to mapped areas.

Mapping

One of the major findings in the studies carried out in the application of the 3-Step Method on an allotment basis is that the mapping of types by condition classes is a necessary prelude to sampling. In following the condition of one allotment over a period of years the average condition of the allotment or even of a major type within it has little

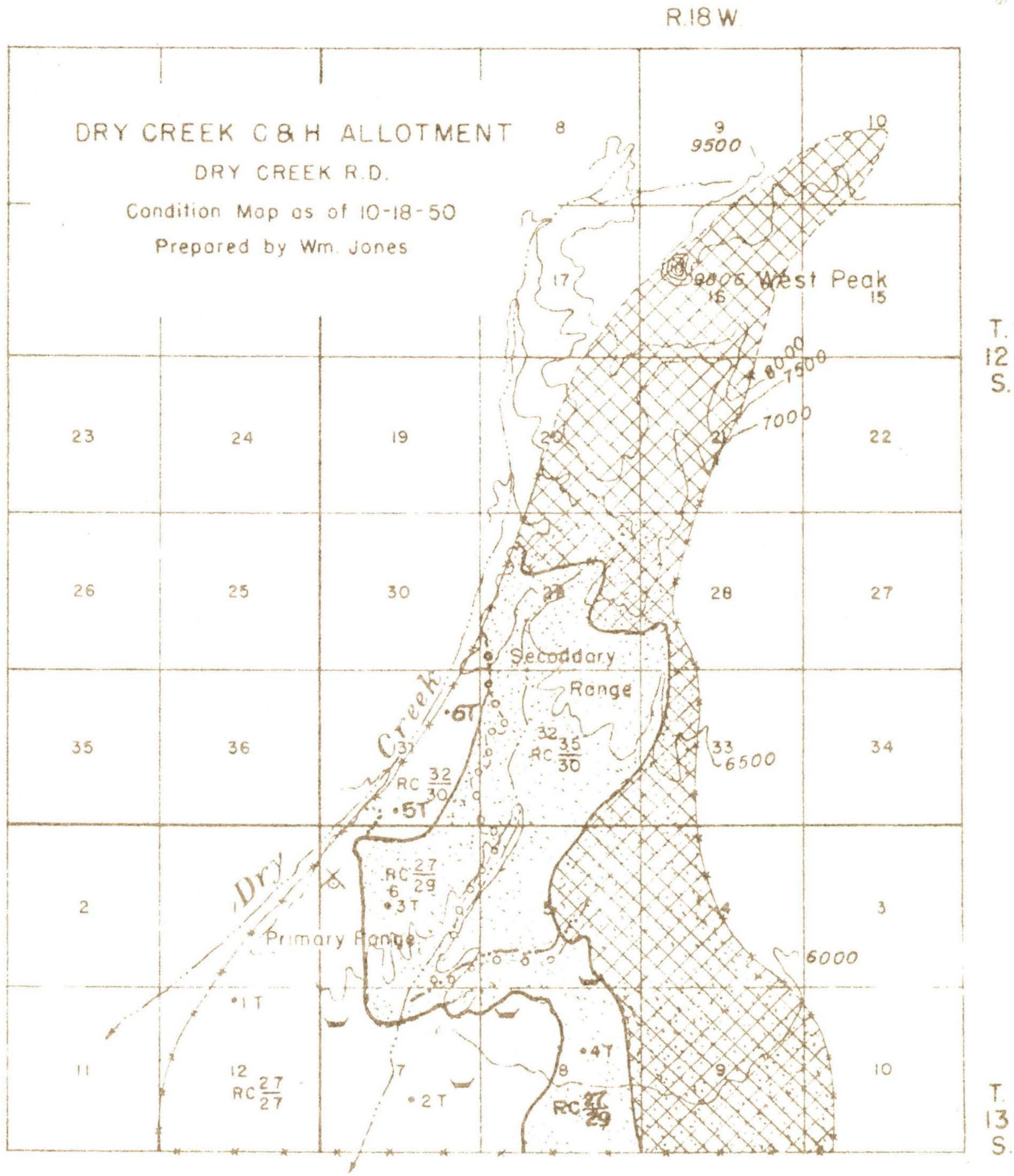
significance. Take the case of the Flagtail allotment[1/] in Oregon,

1/Progress report on Flagtail Condition and Trend Methods Study. Prepared by Joseph F. Pechanec, dated February 19, 1951, in files, Pacific Northwest Forest and Range Experiment Station, 40 typed pages.

where the ponderosa pine type makes up the major portion of the area. Under moderate grazing use the ponderosa pine type will be lightly utilized unless the meadow and sagebrush-bitterbrush types are severely overused. To average the three types as to change would be meaningless. Similarly it would be misleading to average the change in condition within a single type. For example, parts of the meadow type may be in good condition and the cover of Nebraska sedge actually improving whereas at the same time adjacent drier parts are being badly damaged. Findings from the Flagtail study further indicate that for following trend transects need not be located within the lightly used types or portions of the area. In the case of the Flagtail allotment this would largely eliminate the ponderosa pine type.

Mapping includes segregation of unusable areas from usable range, the designation of primary and secondary range within the usable areas, and the delineation of major plant communities and condition class lines within the usable range. These categories are defined as follows:

1. Unusable ranges are those areas which are of no value for livestock use because of topography, barrenness, distance from water and dense timber and areas which have been closed or should be closed because of highly erodible unstable soils or extreme deterioration. The size of the unusable range will vary to some extent with the kind of livestock. For example, sheep can be grazed in rougher topography and farther from water than cattle. Research findings on factors affecting



Grassland

Woodland

Unusable (Waste or very poor condition).

•3 T Transect cluster

RC Condition Rating

Separation Primary-Secondary range.

K.P 4-5-51

Figure: [illegible]--Map delineating unusable areas, primary and secondary range areas, vegetation types, condition classes, and location of transect clusters.

grazing use such as Glendening's (19) work in the Southwest should be used as the guide in separation of unusable areas from usable range.

Ordinarily the unusable areas can be sharply defined, as shown in figure 10, and segregated from the usable range. In some instances they may be so intermingled as to require an undue amount of time in mapping. In such cases the area should be shown on the map with an estimate of the percentage area occurring in the two segregations.

2. Usable range is that which has value for and can be safely grazed by livestock. It is divided into primary range and secondary range.
3. Primary range is that which furnishes the bulk of the forage to range livestock and includes the most accessible parts of the allotment such as meadows, open parks, canyon bottoms, and openings within brush and timber types. Ordinarily the primary range area will be overutilized before cattle are forced to intensively graze other parts of the allotment. Because of its ready accessibility, especially to cattle use, it comprises the parts of the range which are most likely to reflect change in condition whenever seasons of use, numbers of livestock, or other management features are manipulated. Accordingly, the primary range area is where the line transect clusters should be established. The broad general plant communities are subdivided as to condition class boundaries.

Five condition classes for vegetation and soil are recognized: excellent, good, fair, poor, and very poor. Final ratings, as described later, are assigned only after completion of transect installation and measurement. To do this effectively requires thorough

training in and familiarity with criteria for judging condition of vegetation and soil. Uniformity between men is secured through the field use of range condition and trend score cards such as shown in figures 5 and 6. If standards for judging condition are not defined as to condition classes, the different condition situations will have to be mapped as they occur. Condition situations may occur where the individual areas are so small as to require a prohibitive amount of time in mapping. For example, topography may be broken so that north and south exposures alternate rapidly—with northerly exposures in good condition and southerly exposures in fair or even poor condition. These should not be averaged but should be shown on the map with an estimate of the percentage area within each condition class.

Judgment of density and composition as entailed in application of the condition score card for preliminary ratings of the condition class area can be checked by means of the paced transect. This is accomplished by attaching the loop or ring instrument to a cane, taking 100 full paces through the area, with an observation recorded at the end of each pace. Readings are made by a simple dot tally but otherwise as in the case of Step One.

In most instances primary and usable range will be determined on the basis of the kind of livestock currently grazing the range and under existing management and improvement facilities. Where range is used in common, as by both cattle and sheep, usable areas should be classified separately as to each kind of livestock. The size and delineations of primary range are subject to change because of recent range improvements such as the construction of stock trails and development of stock water within the secondary range area.

4. The secondary range area is comprised of the remaining land areas after delineation of the primary range and unusable areas. On range grazed by cattle these are the areas without permanent stock water; i.e., lands beyond one mile from water in rough topography or 2 miles beyond water in rolling or level terrain. They may be grazed occasionally by drift livestock but for the most part it will be light use whenever the primary range is properly stocked. The condition classes in the area need not be delineated but it should be examined closely enough to permit estimation of percentage acreage within each condition class. The general broad vegetation types should be shown.

Tests of the accuracy of segregating range as to usability, vegetation types, and condition were conducted on the Sacaton allotment on the Gila National forest in New Mexico.[2] Five two-man crews traversed

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[2] Office report entitled "Sacaton test of southwestern range condition rating procedure," dated April 9, 1951, prepared by C. Kenneth Pearse, in files of Southwestern Forest and Range Experiment Station, 6 typed pages.

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and mapped the allotment (shown in figure 10) independently. All of the men had had range survey experience and additional training for the purpose of conducting the tests consisted mainly in a briefing on the specifications and instructions. The maps prepared in a day's time by the five crews showed a general similarity. All crews agreed that each of the two types within the primary range area consisted of only one condition class. Summarization of the acreages involved in the various classifications is presented in table 19.

It will be noted that the crews segregated the unusable areas from the usable more accurately than they did in delineation of the vegetation.

Table 19.—Comparison of acreage classifications by five two-man crews of the same allotment

Crew	Primary range: Total area	Primary range: Grassland	Primary range: Woodland	Unusable range
	(Acres)	(Acres)	(Acres)	(Acres)
A	1,990	1,250	740	4,250
B	1,970	1,160	810	4,270
C	2,230	1,120	1,110	4,010
D	2,200	1,520	680	4,040
E	1,820	1,050	770	4,420
Mean	2,042	1,220	822	
S	171.38	186.62	167.84	
Coefficient variation	8.39%	14.97%	20.42%	

This is indicated by the coefficient of variation for the total area of primary range. The 8.39 percent indicates that if other men with similar training and background were used to map the allotment, two-thirds of the determinations would be within about 8 percent of the mean of 2,042 acres. The greater variation within the vegetation types is attributed to lack of clear-cut boundaries since there was intermingling of grassland with scattered trees and narrow woodland stringers. The general conclusion from the Sacaton trials was that the mapping procedure was satisfactory in giving repeatable and accurate information on classification of the range as to usability and vegetation types.

It is unfortunate that in the Sacaton test there was not greater variation in the condition of the primary range. The findings of Reid and Pickford (40) indicate that in range survey subtypes (similar to condition classes) the variation in mapping is similar to that in mapping major types. The variation in mapping subtypes was found to depend largely on the nature of the change that separates it from the surrounding vegetation. Subtypes with distinct boundaries were recognized and

mapped as closely as major types by different men. Subtypes with indistinct boundaries were classified similarly but the boundaries varied widely between the men mapping.

In spite of the difficulties and problems involved in accurate mapping it still remains an essential step in the procedure for following trend on an allotment basis. Greater accuracy in mapping will be forthcoming only as rapidly as criteria are developed and training of personnel intensified. Mapping simplifies the job and reduces the cost of sampling an allotment for trend, because it restricts the sites to be sampled to those areas which can be expected to change because of range management. Mapping and subsequent sampling are interdependent, as Klapp (25) points out it is only through areas that have been closely studied that we are afforded a critical basis for the survey of larger land tracts. Without mapping can be likened to determining the nature and contents of several sacks of unknown material. By sampling we may determine that some are sugar and some are salt but we won't know how much there is of each until we count the sacks and weigh or measure the size of each sack.

Installation of Transects

Immediately following the preliminary mapping of the allotment, the primary range areas are sampled with permanently located transects by the 3-Step Method. The location of the sites for the transects established are shown directly on the map (figure 10). Notes on their exact location, the end from which measurements start, are entered directly on the back of the transect data form. The main problems involved in the establishment of transects are: How many transects to locate in a cluster, How to select the sites for establishment of clusters, and how many

transect clusters are necessary to sample at an acceptable level of accuracy, the condition class areas delineated on the map for ultimate determination of trend.

The intensity with which the study of trend on an allotment is undertaken depends on just how much time and funds that the administration decides can be warranted. In the case of "problem" allotments he will no doubt want a high level of sampling accuracy. Sampling techniques, procedures, and statistical methods for precise determination of errors in sampling are readily available from Range Research. Ordinarily, administrative needs will have to be satisfied with the bare essentials; which often may not be subject to ready statistical analyses. Both extremes will be considered in the following sections pertaining to the transect as a sampling unit.

1. Why transects are placed within a cluster.—Two or more transects are placed in a cluster at each sampling site. There are several sound reasons for doing this. It affords a larger sample of the vegetation and helps prevent the overlooking ofrare species which may have important indicator values. It provides a measure of the variation within a sampling site and helps smooth out the differences in measurement between men. From a practical viewpoint, placement of transects in clusters is desirable because of the greater amount of information obtained per man hour. The question of how many transects that should be placed in a cluster will be governed by the variance in the density index of vegetation both within transect clusters and between clusters. In addition to this, the number of transects in a cluster will be governed in part by the ease of travel. If travel is easy it is better to have fewer transects in a cluster and more clusters established for sampling the range. If travel is difficult or lengthy, cost in terms of time becomes a

limiting factor and more units in a cluster, with fewer clusters, will be required.

As an example of the increased efficiency resulting from placement of transects in clusters analysis of data (<u>36</u>) obtained in the mixed-grama-savannah type of southern Arizona indicated that eight clusters of three lines each (total 24 lines) would be equivalent to 19 independent transect lines separately located. In this instance the travel time between cluster locations was 35 minutes and the time to measure, interpret the data, and take the photos was 40.5 minutes per transect. The saving in time by doing the work on a cluster basis is apparent. This saving in time would no doubt be increased in follow-up remeasurements when the same sampling sites would have to be relocated, perchance in rough terrain and by personnel unfamiliar with their location.

For ease in relocation, it is advisable to mark the location of transect clusters with a witness stake or post. A 5-foot steel fence post driven 2 feet into the ground is recommended. Since this is apt to attract livestock it should be a minimum of 50 feet from the nearest transect.

2. <u>Number of transects to place within a cluster</u>.—Methodology for the calculation of the optimum number of transects per cluster has been previously reported (<u>36</u>). In the Flagtail allotment study it was determined that two transects per cluster in the ponderosa pine and sagebrush-bitterbrush types and one transect per cluster in the meadow type were adequate. In the mixed grama grassland of the Southwest where vegetation is naturally more sparse, three transects appear to be the optimum. Additional study is needed in all regions for all range types to provide reasonably reliable guides. Until this is accomplished it is suggested

that a minimum of three transect lines be placed in a cluster where the index of plant density is below 20; from 21 to 60, two transects; and above this, or 61+, one transect per cluster.

3. <u>Selection of sites for the transect clusters</u>.--In cases where it has been decided that trend should be followed by the most intensive means available, sites for the location of transect clusters should be selected within each condition class of the primary range purely at random. The reason for this is that the data may be examined by statistical means to determine the exact number of transect clusters necessary for meeting the level of accuracy desired. This can be accomplished only through preliminary sampling and immediate analysis of the data. By randomization it is always possible to determine the error of sampling.

In the usual situation, sites will be selected arbitrarily on the basis of being "representative" of the condition situation. In either random or arbitrary selection of sites, transect clusters must not be located in areas where livestock normally concentrate, as on salt grounds, fence corners, or adjacent to permanent stock water. They should be a minimum of 100 feet from any fence, including exclosures, and in dry upland types in rolling to level terrain 1/4 mile from permanent water.

One of the objectives of the Sacaton allotment tests in New Mexico was to evaluate the accuracy with which selected locations depicted actual conditions as compared to purely random locations. As shown by the summarized data in table 20, the deliberately selected locations had a significantly higher forage index density by the loop method than the random locations. Consequently, the vegetation score card rating for this factor was likewise higher. This indicates a real bias between men in the selection of areas which they considered to be representative with

Table 20.—Comparison of loop measurements and score card ratings between Random and selected sites in grassland

	Loop method measurements				Score card ratings							
					Vegetation rating				Soil rating			
	Total density	Forage index density	Litter	Bare soil	Density	Comp.	Vigor	Total	Ground cover	Ero	Profile	Total
Random												
Mean 1/	17.17	14.58	19.21	22.14	2.50	4.80	3.70	11.00	3.10	3.60	3.60	10.33
S	6.10	6.07	6.66	12.69	.99	.94	.72	1.20	.35	.74	.74	1.18
C.ofV.	35.53	41.63	34.67	57.32	39.60	19.58	19.46	10.91	11.29	20.56	20.56	11.42
Selected												
Mean 2/	23.41	20.25	17.42	22.88	3.60	4.90	3.50	11.92	3.20	3.80	3.50	10.50
S	4.43	4.37	4.14	9.92	.65	.64	.53	1.33	.46	.46	.53	1.07
C.ofV.	18.92	21.58	23.76	43.36	18.06	13.06	15.14	11.16	14.38	12.10	15.14	10.19
T	1.808	2.330*	.688	.143	2.818*	.268	.685	1.693	.582	.694	.338	.340

1/Means based on average of 15 clusters (3 lines per cluster)
2/Means based on average of 10 clusters (3 lines per cluster)
*Significant difference between random and selected means at 5 percent level.

respect to the forage density index. In most instances, however, the coefficient of variation is greater for the random than for the deliberately selected lines. This indicates that the men were successful in selecting locations which avoided the extremes, yet, except for the forage density index, were able to select areas fairly representative of actual conditions on the ground. The percentage mean errors (percentage of the mean, made up by the standard error of the mean) for score card ratings at the random location were: Vegetation—density index 10.2, composition 5.1, vigor 5.0, and total rating 2.8; soil—ground cover 2.9, erosion 5.3, profile 5.3, and total rating 2.9. The general conclusion following this test was that it offered good evidence of the ability of adequately trained men to select areas that are generally free from bias and will portray the average of a condition class within a given vegetation type—in this case, grassland.

4. <u>Number of transect clusters necessary for sampling</u>.—Where the sites for transect clusters are deliberately selected a minimum of two clusters per condition class is suggested.

Where the locations are randomly made the number will vary with the level of accuracy desired and also with the range in variation of the factor selected. Take the case of the Sacaton allotment tests. On the basis of score card ratings for vegetation, analysis indicated 2 clusters as necessary to attain the 10 percent level, whereas for the 5 percent level 48 clusters would be needed. In most instances the administrator will have to be satisfied with percentage mean errors approaching 10 percent because of the prohibitive costs involved in attaining higher levels of accuracy. For most biological material this is generally regarded as adequate.

The number of transect clusters necessary to sample a condition class area to any given degree of precision can always be determined from a preliminary sampling of the area followed by statistical analysis of the data for the variance and utilization of the following relationship of N (number of plots): $T^2_{\bar{x}} = \frac{Tx^2}{N}$

Wherein the desired variance of the mean $T^2_{\bar{x}}$ is deliberately calculated as a percentage (i.e. 10 percent) from the mean of the preliminary sample and Tx^2 is the actual variance of the sample.

As previously indicated the number of transect clusters or plots required is greater in sparse vegetation than in dense. This is readily apparent from the data presented in table 20.

Table 21.--Number of transects required to reduce the standard error of the mean to within 10 percent of the mean (based on data from Region 3 Range Study Plots)

	Reconnaissance density in percent							
	5	15	25	40	50	60	70	80
Number of transects required	55	42	33	22	16	10	5	2

The number of transect clusters required to attain a given level of accuracy will also vary with the constancy of the element being analyzed. In other words, it will require fewer transects to accurately portray the mean density index of the total of all species than it will for the individual species. This is shown conclusively by the data presented in table 22. It is obvious that to pick up rare species (i.e. in this case threeawn) accurately that a prohibitive number of transects would be required. It is for this reason that rare indicator species are simply listed on the field form as occurring on the site and no attempt is made to pick them up by measuring additional lines. In most situations computation of the number of transect clusters required should be based on the forage density index.

Table 22.--Number of transects necessary to reduce percent mean error to 5 and 10 percent levels of accuracy for total grass and by species (Jornada Experimental Range Forage Crop Weight data)

	Number of transects necessary for 10 percent level	Number of transects necessary for 5 percent level
Total grasses	12	50
Black grama	22	89
Sand dropseed	106	425
Threeawn	650	2,599

The number of clusters required in random sampling will also vary with the vegetation type. For example, in the Flagtail allotment tests it was found that for similar situations and for the 10 percent level

22 clusters (2 transects per cluster) should be used in the open forest (ponderosa pine), 20 clusters (one transect each) in the meadow, and 25 clusters (2 transects each) in the sagebrush-bitterbrush type.

5. Proper length of transect lines.--Another factor which has been found to influence sampling efficiency within a given site is the length of transect line. This has been given some study at the Southwestern station in connection with the line intercept method. A summary of the analysis is presented in table 23. It will be noted that the longer the line the more efficient is the sampling unit--for example, transect lines 50 feet long will supply as much information at twice the level of accuracy as lines 10 feet long. It is for this reason that transect lines 100 feet long are recommended for step one. As previously indicated, however, there will be situations where shorter length lines such as 50 and 25 feet are more suitable.

Table 23.--Comparison of the efficiency of different length transect lines for sampling the mixed grama type (based on measurement of 20 lines of each length indicated)

	Length of line - in feet				
	10	20	30	40	50
Percent mean error for 20 lines	16.79	14.69	9.94	9.34	8.38
Number of transects necessary to attain 10 percent level of accuracy	57	44	20	18	14

6. How transects are arranged within a cluster.--Keeping in mind that each transect is regarded as sampling a plot (in the case of a 100-foot transect a plot (150 x 100 feet), transects may be arranged in any pattern desired within clusters where the sampling sites are deliberately

selected. For example, this may be end to end or side by side. Where they are placed end to end they should be separated by a space of 100 to 300 feet in order to secure a wider representation of the condition class. Where they are placed side by side they should be a minimum 100 feet apart. Transect patterns radiating from a central hub should be avoided becuase if the central hub is destroyed all transect locations become lost. Wherever possible, transects should always be placed parallel to the contour because this permits sampling drainages by cross section, the transects are less subject to complete destruction as by skid logging, and on steep slopes they are easier to measure.

Where cluster locations are randomly located, the transects within the cluster must also be randomly placed. Several ways of doing this are available. One way, where it is desirable to place the transects in a straight line, is to visualize a line 500 feet long divided into five equal segments, numbered consecutively 1 to 5. Two of these numbers, in the case of clusters with two transects, are drawn at random and these two comprise the transects to be measured. Another way is to visualize a large plot such as one 800 x 150 feet divided equally into eight subplots and again numbered consecutively. If three transects are desired in the cluster, three of the possible eight numbers are drawn at random.

Several different cluster patterns may have to be utilized on the same allotment. Where the condition class area is broad and extensive, the linear arrangement is best. Where the condition class area is narrow and restricted, as in meadow stringers, the block arrangement of subplots is most suitable because the subplots can be more easily arranged within the confines of the condition class boundaries. A deck of playing cards serves well as a means for drawing random numbers.

Final Field Check of Primary Range Area

Transect clusters are measured, the data summarized and interpreted on the site at the same time the clusters are staked out. Where the transect clusters are arbitrarily selected as to sites, the ratings obtained on vegetation and soil are used as a base to rate the remainder of the condition class area. The ratings assigned to the areas may vary several points above or below the cluster averages. Various evidence not found on the sites sampled by the transects may warrant a different rating. For example, accelerated erosion may be more pronounced outside than inside the cluster sites and the soil rating would be accordingly reduced. Or remnants of the original cover may be sparse but conspicuous and reproducing and the rating for vegetation raised. The final field check may also result in map changes, particularly within the primary range area as to different condition situations.

The clusters serve mainly as permanent "bench marks," or definitely marked plots to which subsequent examiners can always return to as a starting point for periodic re-examinations. They also serve as inspection points for field supervisors to check the thoroughness of work being accomplished. It is unlikely that the trend as determined by later measurement and comparison of data on clusters will be in one direction and that of the condition class area in the opposite direction. If such should occur in the future the cause should be determined and if necessary additional clusters be established.

Final ratings for both vegetation and soil within each condition class are entered directly on the map, as shown in figure 10.

Final Office Work

Although the bulk of the summarization of data and its interpretation is accomplished directly in the field, there still remain several jobs which are best completed in the office. These include final preparation of maps, an allotment summary, and filing of data.

Final Map Preparation

Final map preparation includes the transfer of the essential information from the aerial photos (if these have been used) to the base map. Ordinarily it will not be considered necessary to color the maps. Simple cross hatching of the unusable range as in figure 10 helps focus attention on the usable parts of the area. If color is used the following legend is standard:

Alienated land—Lake red (Mongol 966*, Dixon 321½). Where it is desired to indicate the range-condition class of lands waived under Reg. G-3(d), use the condition-class legend, but outline the boundaries of the private land in lake red.

Unusable Range

Areas closed to grazing—Orange (Mongol 962, Dixon 324). Areas that are proposed for closing will be cross hatched in orange.

Waste range—Blue-green (Mongol 998, Dixon 320½). Includes all areas within a grazing allotment that have little or no value or are not usable by livestock.

Range in very poor condition—Yellow (Mongol 917).

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*The Mongol 800 series is identical in color to the 900 series.

Usable Range

Range in excellent condition--Sky blue (Dixon 320).

Range in good condition--Violet (Dixon 323, Mongol 944).

Range in fair condition--Purple (Dixon 323½).

Range in poor condition--Pink (Dixon 322, Mongol 946).

Reseeding areas--In proposed areas for reseeding the ground color will be that of their condition class, but the area will be outlined and ruled with diagonal lines in bright-blue ink. When the proposed reseeding area has been planted, diagonal lines in the opposite direction will be added, making the area cross hatched in bright-blue ink. The word "Reseeded" or "R" and the year of the planting will be used to distinguish such areas.

Areas on which eradication of noxious plants is needed and feasible will be outlined and ruled with diagonal lines in green ink. When the proposed treatment has been accomplished, diagonal lines in the opposite direction will be added, making the area cross hatched in green ink.

The location of permanent transect-line clusters will be shown on the map in black ink with a "T" and the number of the cluster appended, i.e., "3T".

The rating for the condition class within the type will also be shown. For example, RC $\frac{13}{14}$ vegetation-condition score / soil-condition score

Allotment Summary

Following the final map preparation, the acreages for the unusable areas, the various categories of usable range, together with their ratings as to vegetation and soil condition, are entered into a summary form such as shown in figure 11. Acreages are readily estimated by means of a dot

ALLOTMENT SUMMARY OF RANGE TREND DATA

Allotment ______________________ District ________________

MAP DATA

YEAR OF RECORD

Kind of range	19 Acres	19 Rating*	19 Acres	19 Rating	19 Acres	19 Rating	19 Acres	19 Rating
UNUSABLE RANGE AREA								
USABLE RANGE AREA								
PRIMARY-Type ________								
Excellent								
Good								
Fair								
Poor								
Very poor								
TREND OF TYPE								
PRIMARY-Type ________								
Excellent								
Good								
Fair								
Poor								
Very poor								
TREND OF TYPE								
SECONDARY-Type ________								
Excellent								
Good								
Fair								
Poor								
Very poor								
TREND OF TYPE								

*Rating = record for both vegetation and soil; i.e., 30v27s

TRANSECT CLUSTER DATA ON RATINGS OF CONDITION

Cluster number	Vegetation 19	Vegetation 19	Vegetation 19	Vegetation 19	Soil 19	Soil 19	Soil 19	Soil 19
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
TREND								

(See other side for recording remarks)

Figure 4.—Form used to assemble and maintain range trend data for several years on an allotment.

template designed specifically for this purpose or by planimeter. Space is also provided on the form for the final ratings assigned at the transect clusters.

This form is a permanent long-time record, providing space for summarization of data in subsequent years. Ordinarily the transects would be remeasured every 2 years and the mapping at longer intervals of 4 to 6 years time.

The back side of the form, or by means of appended extra sheets, is used for entering essential notes pertaining to the history of the allotment. For example, unusual drought years, changes in season of use, changes in kind of livestock as from cattle to sheep, changes in numbers of livestock, unusual build up of big-game numbers, years of extremely heavy over or under utilization, etc., all of which is essential to the determination of the causes of ultimate trend.

Filing of Data

The data and maps, when completed, will be marked "Permanent Record--Do Not Destroy." They will be filed allotment by allotment in the G-MANAGEMENT folder for that allotment in the district ranger's files. Copies will be made for the supervisor's files at his discretion. The best actual use records available should be maintained in the same folder and filed annually. These data will eventually form the historical record of the trend in range conditions on that allotment and the action that has been taken to improve and maintain the range resource.

Application on Allotments Where Condition Standards Are Lacking

As previously reported (35), several of the western regions do not as yet have condition standards developed for the more important plant communities. In such situations there will occur problems of interpretation

of the data obtained in Step One. This is not an insurmountable obstacle and should never be a valid reason for not undertaking the study of trend in condition on an allotment basis. A situation similar to this was encountered during 1950 in application of the 3-Step Method to the Flagstaff allotment[3/] on the Lewis and Clark National forest in Montana. It was met by careful study of data obtained from an exclosure fenced for 10 years within a moderately grazed portion of the range, study of the more heavily grazed portions near stock water and the application of knowledge gained from similar plant communities. A week's field work was required for these preliminary standards which are summarized in figure 5.

Ordinarily 1 to 2 man years is required to develop adequate criteria for a single range type and should always be utilized whenever available. Criteria developed "on the spot" as in the case of the Flagstaff study should be subject to additional careful recheck whenever the opportunity for doing so occurs. Even though initial adjective and numerical ratings be incorrectly assigned, the original basic field data if properly summarized is easily re-checked later if the need for doing so is subsequently indicated by newly developed criteria. Take the case of the Flagstaff data as summarized in table 24, later findings may indicate that the condition now designated as "excellent" may eventually prove to be only a high good or the "fair" may be better than this. (As it would be if judged on standards from some other regions.) Regardless of the adjective ratings assigned change in the direction of that indicated as "fair" must be judged as deterioration and any change in the opposite

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3/Reported in: Barry C. Park's RR-NRM SUPERVISION-Administrative Studies, Condition & Trend memo of March 2, 1951, 14 typed pages, and "Establishment Report—Trend in Range Condition Flagstaff Management Unit, Lewis & Clark N.F." prepared by M.J. Reed, April 2, 1951, 19 typed pages, files of Northern Rocky Mountain Forest & Range Experiment Station.

direction as improvement. The differences between the three condition situations with respect to composition, litter, moss and vigor is apparent.

Table 23.--Summary of basic field data on three condition situations on Flagstaff allotment (averages of 2 clusters in situations A and C; 1 cluster in B, each cluster 2 transect lines)

	Condition situation		
	A	B	C
Ground Cover			
Total vegetation - Pct.	68	72	66
Litter - Pct.	25	16	13
Moss - Pct.	3	5	18
Bare soil, rock - Pct.	0	2	1
Composition			
Desirable plants - Pct.	83	74	66
Intermediate species - Pct.	10	14	30
Undesirable plants - pct.	7	12	4
Vigor			
Festuca idahoensis-Inches 1/	6.8	4.4	3.0
F. scabrella - Inches	14.7	11.4	-
Forage Condition Rating			
Density index	10	10	10
Composition	15	9	10
Vigor of desirable species	8	6	3
Sum	33	26	23
Adjective description	Excellent	Good	Fair
Erosion hazard	0	0	0

1/Average maximum leaf length.

RECOMMENDATIONS FOR FURTHERANCE OF THE CONDITION AND TREND JOB

In the furtherance of the condition and trend job on Western National Forest ranges there are several recommendations which need to be made as to conduct of the work in the future. These relate mainly to: Maintenance of records, continuance of previous administrative studies,

training of personnel, estimated costs of doing the work, and assignment of responsibility for most effective accomplishment of the work.

Maintenance of Records

During the course of the condition and trend study considerable contact was made with administrative personnel with regard to the maintenance of records. It was apparent that records on an allotment basis in all regions have, in the past, been highly unsatisfactory. Records that have been maintained are usually fragmentary, nonspecific, and often devoted to inconsequential personal happenings. In all too many instances, the records have been poorly maintained and in some cases deliberately destroyed so that a history of allotment grazing use and other information which would be helpful in tracing condition and trend is no longer available. A few examples will serve to illustrate. On one forest the allotment records and livestock association files for the period previous to 1939 were arbitrarily destroyed in order to "clean up the files." There are many instances wherein the original range survey data have been lost or destroyed. Just recently in one region the files on an important long-time study, which had been discontinued, would have been destroyed but for the interference of a forest officer who realized their value and importance. All such data and records should be plainly labeled—PERMANENT RECORD—DO NOT DESTROY.

In recent years, there has been concerted effort made to tighten up on records of condition and grazing use on allotments by insistence of frequent and regularly made inspections and in the issuance of instructions for maintenance of better records. Forms which require a record of essentials have been developed and are in use in several regions. In spite of these efforts, there is still considerable need for improvement. In

all regions, however, there is universal complaint that the ranger's work load is so great that time is not available for adequate yearly inspections of range units and the maintenance of necessary records.

Continuance of Previous Administrative Studies

The Forest Service, since its establishment as a bureau in the Department of Agriculture in 1905, has been especially concerned with the condition and trend of some 85 million acres of National Forest range lands--under its jurisdiction in the West. Numerous administrative studies, involving hundreds of plots open to grazing use and hundreds of fenced plots excluding livestock and in some cases game and rodents, have been undertaken at various times and with varying degrees of enthusiasm. The usual history of these studies has been to initiate the work, collect the data for a few years, and then because of change in personnel or lack of interest, or reduced funds or time available, gradually drop the work without compilation and analyses of data and consequently with no interpretation of results. Much of these data might still be salvaged and be of value in picturing on a regional or forest area basis the trend in range condition. However, in some instances the studies were hurriedly planned and conceived and, in a few cases, were dropped because the results obtained did not bear out the original intent. In some instances the data collected consisted merely of a brief word description or the methods used were subject to a high degree of personal bias. In many of these studies photographs were taken which, if repeated today, could be of inestimable value in piecing together the changes or lack of change that have occurred on National Forest ranges. Another important source of information on range trend is the range surveys that have been made, especially since 1951. Little or no attempt

has ever been made to analyze or compare these with subsequent surveys of the same areas. And yet, as illustrated previously (table12), such records may have real value in furthering our knowledge of condition and trend as well as providing information useful in management of a specific range area.

During the past several years, the photo transect method has been used widely in Region 4 in the sampling of nearly 200 allotments. These installations will provide an invaluable record as to range happenings in the future, provided that adequate follow-up records are taken. If the 3-Step Method or any other method for that matter be adopted westernwide, it would be a distinct loss of time, effort, and information to discontinue such studies. Fortunately, in this case, both the 3-Step and photo transect methods can be (and are now being) readily combined. Likewise in the Southwest a region-wide range study plot program was begun in 1939. AS yet very little follow-up has been made within the ensuing decade although the re-examination of these plots now should provide much information on the magnitude and rate of changes that can be expected to occur with and without grazing use.

In view of the several hundreds of thousands of photographs taken by Forest Service personnel, it seems strange that so few photographs have been repeated from the original photopoint. Virtually none have been retaken in several regions and only a few in most of the other regions. The few that do exist have resulted largely from individual interest and not by planned effort. Within the last year or so, a few of the regions, notably Region 2, have made a concerted effort to get at this job.

Then, too, there are hundreds and possibly more early day photographs that could and should be retraced. In each region there is a

wealth of photographs by the Army, Indian Service, railroad surveys, International Boundary surveys and various expeditions. Recently Schwan in Region 2 retraced the Custer March of July 23-August 4, 1874 in the Black Hills of South Dakota on which a number of photographs had been taken. He was able to relocate the original Custer camp sites in about a dozen instances and surmised that the original photographs had been taken near them because of the cumbersome photographic equipment required in the 1870's. He also found that most of the original pictures were pointed north because of the early day need for bright lighting. Some of the photographs showed marked changes in the vegetation as from tall grass prairie to short grass blue grama. Photographic sources on magnitude and rate of changes in vegetation and soil have as yet to be more fully explored.

Training of Personnel

Training in the field of all personnel expected to take part in establishment and subsequent record taking by the 3-Step Method or any other method is a necessary prelude to initiation of the work on a range unit basis. In addition to instruction in methodology and use of aerial photos in mapping, training is needed in ecological perception and plant identification. By "ecological perception" is meant familiarity with indicators of condition as reported by Talbot (46), McGinniew et al (31), and Ellison and Croft (18). In plant identification personnel must be able to identify the bulk of the important key indicator species not only by the floral parts but also by the more difficult to recognize vegetative characteristics.

Estimated Costs Involved

In view of the present National emergency it is essential that any additional funds, as might be required in the undertaking of an intensive

program of work such as the condition and trend of National Forest ranges job, be kept at a bare minmum. Accordingly, if the 3-Step Method for sampling ranges to follow trend should be adopted on a western-wide basis it is not anticipated that additional funds will be forthcoming nor will they be necessary. There will need to be, in some instances at least, rather drastic shifts in work loads, activities and responsibilities in order for the ranger to play an essential active part in the work.

In the administration of National-forest range, we are attempting to manage such vast areas that the question of what we would like to do in the way of record taking on condition and trend is largely colored by what we can do with the limited funds and personnel available. The application of the 3-Step Method, or any other method for that matter, at an acceptable statistical level of sampling for each and every one of the some 10,000 grazing allotments in the West is not feasible. The problem becomes simpler if we recognize that on most National forests and ranger districts, allotments can be segregated into three or more groups. For example: one group of allotments, where range conditions are generally satisfactory and there is little need for anything more than routine inspections; a second group where range condition is unsatisfactory and trend is uncertain and where more detailed information is neede then would be supplied by the ordinary inspection; and a third and usually small group of allotments where condition and trends are highly controversial and where the most factual record attainable is required. To meet these three situations, the method applied for following trend must be flexible and supply information whose continuity will not be broken by later adaptions. Some allotments listed now as noncritical may later become so, necessitating a more careful check. The 3-Step Method appears to meet this requirement

of flexibility. On most allotments, the intensity of sampling that is possible is limited. The method that is utilized must combine precise methods of measurement with extensive widescale estimates. The precise method should provide bench marks for repeated measurement and as definitely marked points to which we can constantly return to check personal judgment of the general condition within a large extensive type. Use of the 3-Step Method anticipates this need.

In the first group of allotments mentioned above, it would seem advisable to apply the 3-Step Method at the minimum sampling level, to a very few, carefully selected representative allotments. This might include any which are designated as demonstrations of good management. In the second group of allotments, a larger number of representative allotments would be sampled, also at a minimum level of sampling as when the cluster sites are deliberately selected. In the third group, the number of allotments selected would also be limited but the sampling would be on an intensive, strictly randomized basis. As an example, a ranger district might have 30 allotments involved but only six of these would be sampled (and not all of these in the first year) with one allotment in the first group, four in the second, and one in the third.

Much the same way of assigning priorities could be set up for a forest with respect to ranger districts and even for an entire region with respect to individual national forests. Assignment of priorities in this manner will permit a more effective allocation of time by grazing staffmen and personnel from the Division of Range Management.

The amount of time required per individual allotment will vary greatly with the amount of variation and complexity of the range with respect to usability, vegetation types and condition classes, the

roughness of terrain in affecting travel, and the intensity of sampling desired. Where a high level of accuracy in sampling is desired, as may be the case on problem areas, size of the area has little influence on costs other than time required in travel. This is because nearly as many sampling units are required to sample a small area at the same level of accuracy as it does a large area.

Some indication as to the time required to do the job is available from the experience gained in connection with the studies of application of the 3-Step Method on an allotment basis during the summer of 1950. Information on both sampling extremes are available. Take the case of the Sacaton allotment, identical with the area shown in figure 10, a total of 4½ man days was required for the complete job. This is broken down as follows: 1 man day for mapping, 2½ man days (1-2 man crew) for establishment and measurement of transect clusters (4 clusters--12 transects) and 1 man day for office work, including initial preparation for field work. This is not a prohibitive amount of time but it probably approaches the minimum that would be required for a single allotment or management unit.

In the case of the Flagtail allotment, which involved an area of 28,108 acres and was sampled on an intensive, randomized basis, the time required was accordingly much greater. For allotments similar to the Flagtail, which was well traversed with roads but required walking up to a distance of 2 miles, the total time required was estimated at 78 man days. This was broken down as follows: 34 man days for mapping the allotment and establishing the clusters and plots, 29 man days field time in measurement and rating and 15 man days for routine compilation and analysis. The condition and trend job on an intensive basis is probably comparable

in time requirements to a range inventory survey. For the average ranger to take part in the entire job of an intensively sampled range unit, such as this, is out of the question. Obviously a job of this size would have to be done on a project basis but even on a job of this magnitude the ranger should spend a minimum of five days with the crew in mapping and collection and interpretation of data.

The exact time requirements for the various jobs required on an intensive randomized scale, such as on the Flagtail allotment, is itemized in Table 25.

Table 25.--Time requirements for various jobs during Flagtail allotment condition and trend study

	Man minutes
All types:	
Photography, time for general and closeup picture per transect -	13.2
Travel cluster to cluster and to headquarters per man	33.7
To lay out clusters (with random transects) using 2-man crew - - - - - - - - - - - - - - - - - - -	180.0
Open forest type:	
Soil and forage condition ratings, per plot - - - - -	27.1
Lay out and measure line transect, per transect- - -	31.9
Meadow type:	
Soil and forage condition ratings, per plot- - - - -	33.5
Lay out and measure line transect, per transect- - -	50.3
Sagebrush-bitterbrush type:	
Soil and forage condition rating, per plot - - - - -	26.3
Lay out and measure line transect, per transect- - -	39.7

Responsibility for Accomplishment of the Work

The assignment of duties, responsibilities and authority of those connected with the condition and trend work are similar to those involved

in connection with "range resource inventories." For the condition and trend job these should be as follows:

Chief

The function of the Washington office will be to correlate and secure uniformity as to condition standards insofar as possible between the various regions; to aid in the further development and improvement of methodology and to provide funds for special projects.

Regional Forester

There are at least two alternatives for conducting the condition and trend work within a region. (1) On a special project basis (as in the case of range inventory), (2) on a local forest basis. The project basis has much to commend it—such as assurance of fully qualified and best technically trained men to do the job, insurance of complete uniformity in work standards throughout the region and attainment of closer contact by regional office men with the range problems on all forests. It has several disadvantages—in most regions it will require special funds and there is the danger that personnel on the forests will lose interest in the work. In a region where timber management is the most important activity, such as the Pacific Northwest, placing the condition and trend job on a project basis seems best. On the other hand, in a region where range management is of paramount importance, such as the Southwest, the local forest basis seems most suitable. Even if conducted on a local forest basis it will at least require the full time services of one man within the regional office. His duties would be mainly training, inspection of field work, and to secure uniformity in methodology between forests.

Whichever alternative is decided upon it should be the responsibility of the regional office to:

1. Provide leadership, in accomplishment of the condition and trend job.
2. Provide adequate training of personnel.
3. Furnish, with the direct cooperation of Range Research, the condition and trend standards and other technical assistance required in effective accomplishment of the work.
4. Correlate and secure uniformity in work standards throughout the region.
5. Furnish mapping control, base maps, aerial photographs, and whatever drafting is necessary in the case of special projects.

Forest Supervisor

Since the development of range management plans, correlated to meet local needs is primarily a forest activity, it should be the responsibility of the Forest Supervisor to:

1. Collaborate with the Regional Division of Range Management on all phases of the condition and trend work including: ready adoption of condition standards and methodology, and the training of personnel. Where the work is projected out of the regional office he should cooperate fully with the survey party.
2. Determine with his staff and the District Range involved, the order of priority of areas on which condition and trend work will be undertaken.
3. Make periodic inspections of the work, review maps and other data for adequacy and completeness and take such action as his findings justify to correct practices not in accord with instructions.
4. Where the work is undertaken on a local forest basis, provide the best technically trained staffman with direct responsibility for supervision and accomplishment of the work on the ranger district. Furnish the necessary instructions, forms, equipment, and supplies.

5. Where the work is projected out of the regional office, instruct his District Ranger to assist in the field work and final summarization of data. This job will be provided for in each ranger's plan of work.

<u>District Ranger</u>

Inasmuch as the District Ranger is the land manager responsible for any action taken, and it is he who must put to use the information gained from the records, it is essential that he take an active part in the field work. This would be the case even if the work were on a project basis and would include the mapping, initial installation, and record taking on transect clusters. The ranger also can be of invaluable assistance in the segregation of usable range from unusable areas. It is believed that the average ranger can secure any subsequent records required in the follow-up field examination, excepting the most intensively sampled allotments. Such work should be periodically checked by the grazing staffman for accuracy, adherence to standards, and methodology in order to secure a high level of excellence and to assure uniformity of the work as a forest-wide basis.

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